Office of the Secretary of Defense

REPORT TO CONGRESS

Department of Defense

Long-Term Strategy to Reduce Corrosion and the Effects of Corrosion on the Military Equipment and Infrastructure of the Department of Defense

December 2003

Prepared by the
Principal Deputy Under Secretary of Defense
(Acquisition, Technology and Logistics)

DoD Corrosion Long-Term Strategy
Report to Congress

Introduction

The Department of Defense is pleased to submit this report to Congress, outlining the long-term strategy to reduce corrosion and the effects of corrosion on the Department's military equipment and infrastructure. Tremendous effort over the past year has resulted in a giant first step toward mitigating the safety, readiness, and financial effects of corrosion. Specific accomplishments include the following:

- Establishment of a fully-functioning DoD Corrosion Policy and Oversight organization
- Initiation and promulgation of overarching DoD corrosion policy
- Formation of a multiple-Service Corrosion Prevention and Control Integrated Product Team
- Institutionalization of corrosion prevention and mitigation as a key component of the Department's transformation process through the Planning, Programming, Budgeting, and Execution (PPBE) process
- Development of a project plan template that will be completed for each new DoD corrosion-related project (Key elements include technology, schedule, budget, benefits, return on investment, operational readiness, and management support.)
- Creation of a DoD corrosion website that enables the near-real-time exchange of corrosion-related information and collaboration on corrosion projects, products, specifications, training, and prototype testing
- Establishment of communication links with various private-sector corrosion activities (such as NACE International) in order to strengthen data-sharing
- Development of a corrosion project "road map" that identifies specific projects that, if funded, would prevent or mitigate corrosion based upon mission requirements.

Despite these and other actions, there is much activity to be planned, resourced, scheduled, and accomplished. This report describes the long-term strategy DoD will employ to successfully meet its corrosion prevention and mitigation objectives.

Report Requirement

Section 1067 of the Bob Stump National Defense Authorization Act for Fiscal Year 2003, Public Law 107-314 (NDAA), enacted 10 U.S.C. 2228. Section 2228 requires the Secretary of Defense to designate an official or organization to be responsible for the prevention and mitigation of corrosion of military equipment and infrastructure. It also requires the development and implementation of a long-term strategy for corrosion prevention and mitigation. Subsection 1067(d) requires the Secretary of Defense to submit to Congress a report on the long-term strategy not later than 1 year after the date of enactment of the NDAA. This report is submitted in response to the requirement established by Subsection 1067(d).

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Section I
Strategic Direction

> It is simply good sense and good management to prevent corrosion through better design and selection of materials, and to reduce treatment costs by detecting corrosion earlier and more precisely. Fighting corrosion is just one of the things that we need to constantly do so that we are always ready to perform the fundamental mission of the Department, which is to maintain our national security.[1]
>
> Honorable Michael W. Wynne
> DoD Corrosion Executive

Background

The Department of Defense acquires, operates, and maintains a vast array of physical assets, ranging from aircraft, ships, ground combat vehicles, and other materiel to wharves, buildings, and other infrastructure. These assets are subject to degradation due to corrosion, with specific effects in the following areas:

- Safety—Several weapon system mishaps have been attributed to the effects of corrosion.
- Readiness—Military assets are sometimes out of commission due to corrosion deficiencies.
- Financial—The cost of corrosion to the DoD is estimated to be roughly between $10 billion and $20 billion annually.[2]

DoD has a long history associated with corrosion prevention and control. The Department has been a leader in many areas of research (ranging from understanding the fundamentals of corrosion to applying advanced materials, coatings, inhibitors, and cathodic protection for corrosion control); however, it also has very special corrosion-related challenges:

- DoD's assets are getting older in both relative and absolute terms. The current expected—although often not planned—service lives of some aircraft, missiles, ships, and infrastructure are much longer than any comparable commercial assets.
- In order to perform its mission, the Department must train and fight in all environments, some of which are among the most corrosively aggressive on Earth.
- DoD has unique corrosion-related issues. For example, many coatings used on vehicles and other assets are primarily formulated to perform some special function, such as resistance to chemical agents or maintaining low signature. Corrosion is at best a secondary consideration.
- Like several other DoD efforts, many corrosion activities have been decentralized, which may have decreased their desired visibility and emphasis.
- The Services' existing financial and logistics information systems cannot precisely identify all corrosion-related programs, costs, and impacts.

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[1] *AMPTIAC Quarterly*, Volume 7, Number 4, Winter 2003, page 9.

[2] United States General Accounting Office, *Opportunities to Reduce Corrosion Costs and Increase Readiness*, GAO-03-753, July 2003, page 3.

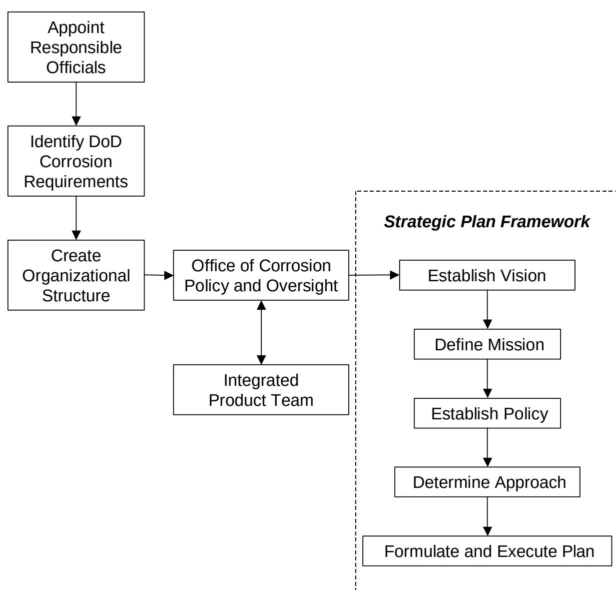
A recent General Accounting Office (GAO) audit recognized DoD's corrosion prevention and mitigation efforts:

> Major commands, program offices, and research and development centers Service-wide have made and continue to make improvements in the methods and techniques for preventing corrosion.[3]

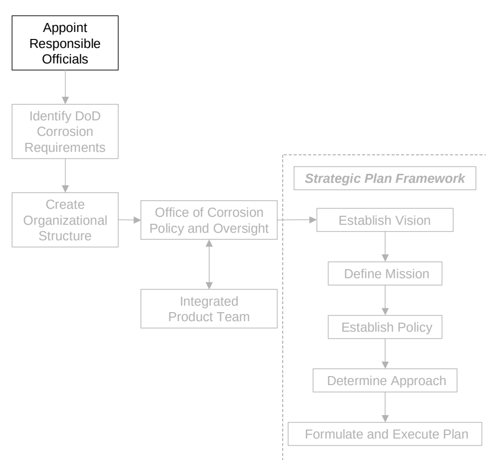
The GAO audit also identified areas in which additional emphasis should be applied, such as the need to establish a long-term strategic corrosion plan, develop outcome-based performance measures, and improve coordination within and among the Services.

This report addresses these and other issues as part of DoD's long-term strategy, which is depicted in Figure I-1.

Figure I-1. DoD Corrosion Prevention/Mitigation Strategy



Responsible Officials



The Deputy Secretary of Defense designated the Honorable Michael W. Wynne (the Acting Under Secretary of Defense for Acquisition, Technology, and Logistics [AT&L]) the Department's Corrosion Executive. In this capacity, Mr. Wynne is responsible for ensuring the overall Department-wide corrosion strategy is implemented. Within AT&L, he established an Office of Corrosion Policy and Oversight to develop and implement a corrosion strategy, and designated Mr. Daniel J. Dunmire (Office of the Under Secretary of Defense [OUSD] for AT&L) as its Director.

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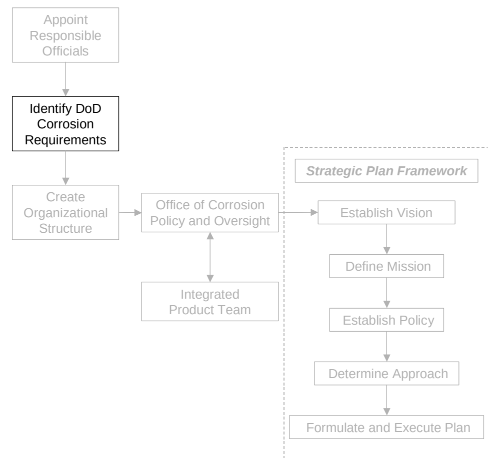
[3] Ibid., GAO-03-753.

Mr. Dunmire oversees and coordinates efforts to prevent and mitigate corrosion of the Department's military equipment and infrastructure. An immediate benefit of Mr. Dunmire's oversight is his ability to organize tasks within the AT&L organization—specifically with the Director of Defense Research and Engineering (DDR&E) and the Deputy Under Secretaries of Defense for Logistics and Materiel Readiness, Acquisition and Technology (Director of Defense Systems), and Installations and Environment.

DoD Corrosion Requirements

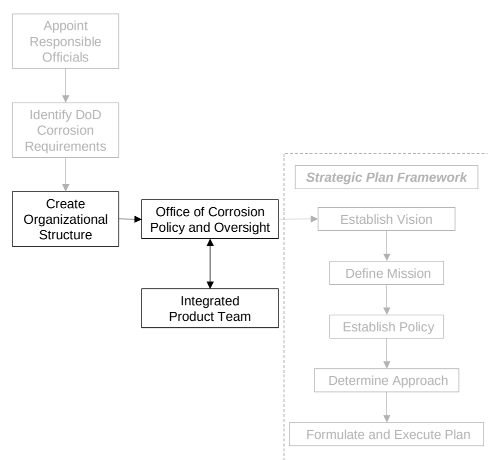


The strategic direction of DoD's corrosion prevention and mitigation efforts is focused on the four quadrants of its facilities and military equipment:

- New (to be acquired) military equipment
- New (to be acquired) facilities
- Existing military equipment
- Existing facilities.

This direction is essential in identifying specific corrosion prevention and mitigation requirements detailed later in this report. In addition, DoD's long-term strategy for corrosion prevention and mitigation must—and does—address each of these quadrants. While some objectives cover all quadrants (such as overarching DoD corrosion policy and a review of corrosion control specifications and standards) other objectives are targeted to specific quadrants (such as the closure of unneeded facilities and the revision of weapon system acquisition policies). Elements of each objective are provided in this report and are summarized in Section IV.

Organizational Structure

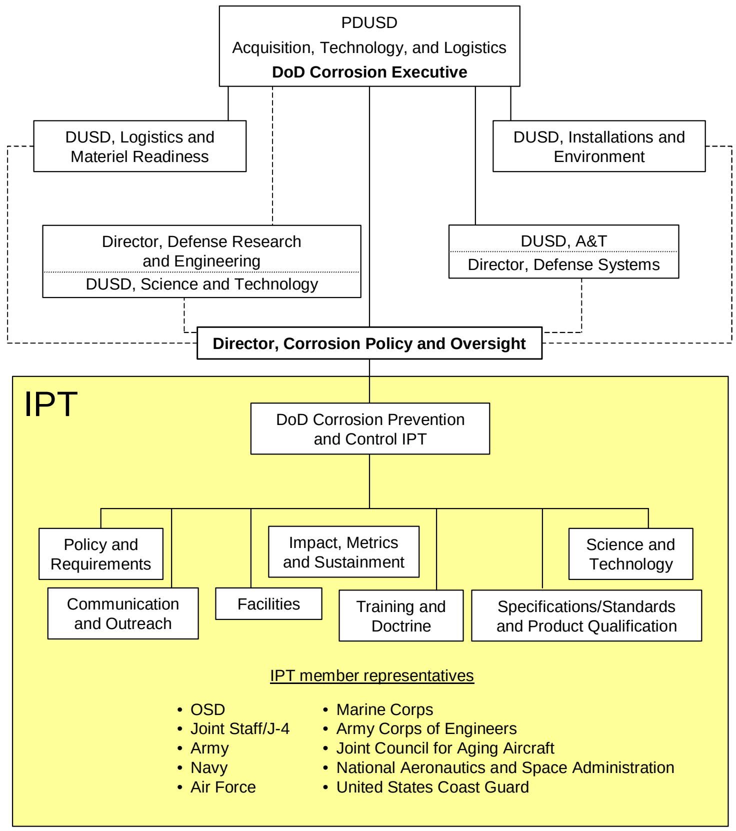


As the first step on this new road to Department-wide corrosion control and prevention, the Office of Corrosion Policy and Oversight created a working group, the DoD Corrosion Forum. Composed of more than 50 technical, management, and policy professionals, the forum's mission was to assist the Office of Corrosion Policy and Oversight in crafting the new DoD corrosion policy.

The forum was also tasked to develop, establish, or identify the documentation, tools and techniques, methods, technologies, outreach programs, and other initiatives needed to successfully implement the new Department-wide policy. The forum fostered a collaborative environment in which members of all professions and sectors contributed to the greater goals of the forum.

The forum recently transitioned into the Corrosion Prevention and Control (CPC) Integrated Product Team (IPT). Figure I-2 depicts the structure of DoD's corrosion prevention and control organization, including the CPCIPT.

Figure I-2. DoD Corrosion Organization



Note: A&T = Acquisition and Technology; DUSD = Deputy Under Secretary of Defense; PDUSD = Principal Deputy Under Secretary of Defense; OSD = Office of the Secretary of Defense.

The CPCIPT is responsible for providing strategic direction, policy, and guidance to prevent and mitigate corrosion of the military equipment and infrastructure of the Department. Following are the specific goals of the CPCIPT:

- Provide strategic review and advice as necessary to deal with
  - an expanded emphasis on corrosion prevention and mitigation;
  - a uniform application of requirements and criteria for testing and certification of new corrosion prevention technologies throughout the DoD;
  - a coordinated approach to collect, review, validate, and distribute information on proven corrosion prevention methods and products; and
  - a coordinated science and technology program that includes demonstration, validation, and transition of new corrosion technologies into operational systems.
- Develop and recommend policy guidance on the prevention and mitigation of corrosion.

- Provide overviews and summaries of the corrosion programs and funding levels proposed and executed by the Military Departments and Defense Agencies.
- Develop a roadmap and monitor the progress of corrosion-related activities.
- Develop strategies to investigate the feasibility of developing methodologies that efficiently track corrosion costs and the effects of corrosion on readiness and safety.
- Provide guidance for improving maintenance and training plans.
- Ensure the use of corrosion prevention technologies and the application of corrosion treatments are considered throughout the life cycle of equipment and infrastructure.

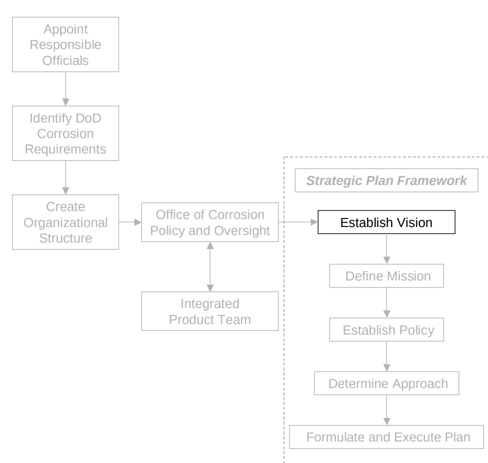
Standing or ad hoc working integrated product teams (WIPTs) have been established to address the various corrosion focus areas:

- Policy and requirements
- Impact, metrics, and sustainment
- Science and technology
- Communication and outreach
- Training and doctrine
- Facilities
- Specifications or standards and product qualification.

The CPCIPT consists of the representatives listed in Figure I-2. Service representatives are generally from weapon system, facility, and research organizations. Additional team members may be nominated by the Director, CPCIPT chairperson, and team members, but must be approved by a majority vote of the team. In addition, while the GAO is not an integrated product team (IPT) member, it is invited to attend/observe IPT meetings and receives copies of relevant documents.

Vision

DoD establishes an overarching, integrated, and effective corrosion prevention and control program for both equipment and infrastructure.



The overall corrosion prevention and mitigation vision reveals a new DoD-wide culture that considers the long-term effects of corrosion, sets boundaries on the cost of corrosion, implements sound corrosion prevention and mitigation policies for both equipment and infrastructure, and establishes realistic metrics to evaluate the effectiveness of these policies and resulting programs. This culture permeates the military, industrial, and academic sectors, creating new paradigms for characterizing, preventing, and treating corrosion and mitigating its effects.

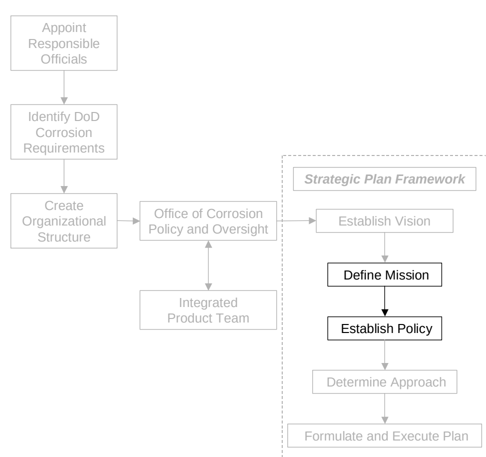
Significant actions by DoD, industry, and academia accelerate the modernization of equipment and infrastructure; close unneeded facilities; improve the corrosion resistance of materials in new products, systems, and facilities; predict the potential for corrosion to occur and its effects; and implement affordable methods of corrosion detection and mitigation. Universities emphasize corrosion prevention, control, and mitigation in curricula devoted to material selection during design. Likewise, DoD implements standard procedures for selecting and applying existing specifications and standards and for revising or creating new specifications and standards. Both military customers and industrial vendors benefit from the standard application of these processes for product or system qualification, verification, and validation.

The responsibility for policy making, strategic direction, and standardization resides with the Office of the Secretary of Defense (OSD). However the Defense Agencies and the Military Departments continue to develop and implement strategic plans that are consistent with Department-wide plans and objectives. The established procedures of each department hold major commands and program offices that manage equipment and infrastructure accountable for achieving the strategic goals. Nevertheless, corrosion prevention is a Joint Service effort, with continuous exchange of technologies, processes, and results.

Rapid and reliable exchange of information is the core of the new corrosion control culture. Researchers, developers, and users from all communities can access reliable corrosion databases, and the web-based Corrosion Information Exchange shares the best public and private-sector practices and results within the corrosion community network. This corrosion prevention and mitigation network continually participates in conferences, councils, forums, and symposia to exchange information and maintain the broad knowledge base of leading-edge technologies; research and development results; technology transition successes; and corrosion prevention, detection, prediction, and treatment processes.

The précis of DoD's corrosion prevention and control vision is one of safe and affordable equipment and facilities that perform at the level of quality for which they were procured; are available to perform their function when they are needed; and can be acquired, operated, and maintained at a reasonable cost. Envisioned are the reduction in corrosion-related mishaps, the increase in equipment and infrastructure availability, and the lowest possible corrosion-related costs (consistent with variables such as equipment age, operating tempo, and funding of corrosion prevention projects).

Mission and Policy



Mission

The DoD corrosion prevention and mitigation mission is to implement a DoD-wide program to standardize and substantially improve strategies, objectives, and processes to prevent, detect, and treat corrosion and limit its effects on military equipment and infrastructure. This mission responds to the Congressional directives and GAO recommendations previously cited. The ultimate objective is to reduce the negative operational effects and associated total ownership cost of military equipment and infrastructure.

Policy

Because the best approach to mitigating the effects of corrosion is to avoid it, DoD will exploit science and technology initiatives in order to develop better materials and designs during the acquisition process to ensure selected materials and approved production processes stave off future corrosion. In addition, continued emphasis will be applied to the implementation of corrosion control, sustainment, restoration, and maintenance of existing defense assets. This dual-tracked policy will stress DoD-wide standardization; interservice and interagency cooperation and communication; effective metrics for evaluating systems, products, and projects in terms of corrosion prevention and mitigation; and implementation of corrosion prevention and control planning as an explicit part of Performance-Based Acquisition and Performance-Based Logistics.

DoD approaches corrosion mitigation as a concept-to-recycling issue, in which planning, production, sustainment, and retirement play important and mutually supportive roles. To implement this policy, DoD's Corrosion Executive, supported by the Director for Corrosion Policy and Oversight and the CPCIPT, has secured the support of all appropriate Pentagon executives. The limiting of corrosion is also a good example of the value of spiral development and evolutionary acquisition. The approaches that work well can be discerned and the methods to incorporate best practices, materials, and processes into new or upgraded systems can be applied.

Overall policy establishes the framework necessary to improve DoD's collaboration, information sharing, and departmental consistency in evaluating and tackling corrosion. Specifically, DoD will concentrate on implementing the best practices and best value decisions for corrosion prevention and control in systems and infrastructure acquisition, sustainment, and utilization. DoD corrosion policy complies with 10 U.S.C. 2228[4] and supports the GAO recommendations cited in GAO audit 03-753.[5]

The following specific policy statements are extracted from *Corrosion Prevention and Control*, a memorandum from the Under Secretary of Defense for Acquisition, Technology, and Logistics to the Military Department Secretaries:[6]

- Reconsider and revitalize our approaches to tracking, costing, and preventing or controlling corrosion of systems and structures.
- Improve our collaboration, information sharing, and departmental consistency in evaluating and tackling corrosion.
- Concentrate on implementing best practices and best value decisions for corrosion prevention and control in systems and infrastructure acquisition, sustainment, and utilization.
- Objectively evaluate corrosion needs as part of program design and development activities and the inevitable trade-offs made through an open and transparent assessment of alternatives.

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[4] Section 1067 of the Bob Stump National Defense Authorization Act for Fiscal Year 2003, Public Law 107-314, enacted 10 U.S.C. 2228.

[5] Op. cit., GAO-03-753, July 2003.

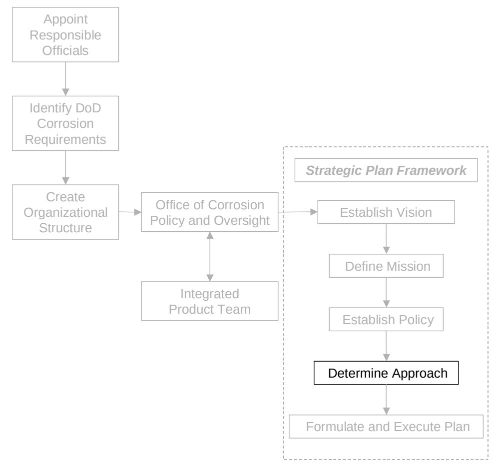
[6] USD(AT&L) memorandum, *Corrosion Prevention and Control*, 12 November 2003, Appendix A.

- Implement Corrosion Prevention and Control Planning as an explicit part of Performance-Based Acquisition in addition to Performance-Based Logistics as defined in DoD Directive 5000.1.
- For programs subject to Defense Acquisition Board (DAB) Review, review and evaluation of corrosion planning will be a standard topic for the Integrating Integrated Product Team reviews.
- The Overarching Integrated Product Team will review corrosion prevention and control planning, with issues raised by exception to the DAB.
- Include corrosion prevention and control planning guidance in the *Designing and Assessing Supportability in DoD Weapons Systems and Infrastructure* guidebook.
- Charter our corrosion action team as a DoD Corrosion Prevention and Control IPT.
- Military departments should review the management level and organizational placement of corrosion program offices to assure their effectiveness and stability.

Section II
DoD Corrosion Management Concept

The term "corrosion" means the deterioration of a material or its properties due to a reaction of that material with its chemical environment.[1]

Approach



DoD has reviewed its existing corrosion prevention and mitigation efforts, and identified areas for improvement. Based upon this review, the Department is revitalizing the approach to tracking, costing, and preventing or controlling corrosion of its systems and structures. Specifically, DoD is developing and implementing plans to improve the collaboration, information sharing, and departmental consistency in evaluating, mitigating, and preventing corrosion. The Department will implement the best public and private-sector practices and best value decisions for corrosion prevention and control in systems and infrastructure acquisition, sustainment, and utilization through training and doctrine.

The choice between investment in prevention or mitigation is determined by analyzing the affordability, readiness, or other appropriate trade-offs for each approach. In general, up-front investment to prevent corrosion should have far greater leverage on total ownership cost reduction than treatment of corrosion during equipment or facility use. In either case, the effect of proposed approaches on system or facility performance, availability, and life-cycle cost is assessed, and the approach that best satisfies these parameters for the life of the system or facility is selected.

The Office of Corrosion Policy and Oversight will provide daily guidance and track the progress and performance of participating groups and component organizations. The DoD Corrosion Executive will maintain top-level oversight and coordination with the Services and other joint stakeholders, such as the Joint Logistics Commanders.

A vital early accomplishment for the program is the institutionalization of corrosion as a key component of DoD's transformation process through the Planning, Programming, Budgeting, and Execution (PPBE) process. The Director of Corrosion Policy and Oversight will submit funding proposals for consideration as part of the Department's program and budget reviews. This approach represents the Department's acknowledgement that corrosion prevention and mitigation are essential to reduce safety, readiness, and financial implications as well as its acceptance that corrosion prevention and control is a continuing, long-term endeavor. This approach also complements already robust Service corrosion projects. The corrosion team will ensure the collective resources are beneficial to as many DoD systems and users as possible.

[1] Section 1067 of the Bob Stump National Defense Authorization Act for Fiscal Year 2003, Public Law 107-314, enacted 10 U.S.C. 2228.

The ill effects of corrosion have long been recognized by a large community of government operators and logisticians. Several influential organizations (such as the Aircraft Structural Integrity Program, the Tri-Service Corrosion Conference, the Aging Aircraft Program, the Tri-Service Facilities Corrosion Working Group, and the government/industry/academic National Shipbuilding Research Program) have been addressing the issue for a number of years. To ensure culture change, the Department must consider corrosion throughout the life cycle of equipment and facilities, and responsible officials must endeavor to make the smartest choices up front, incrementally, and during the whole operational life of defense systems. A driving force behind DoD’s current spiral development and evolutionary acquisition policies is the need to make this kind of approach more natural and less constrained. Hard choices must be made; most obvious is the choice of where funding will be applied. Responsible officials must have the commitment and the data to make the up-front investments in corrosion prevention that will have major payoffs down the line in maintenance and availability. It is essential to maintain the current momentum and focus through commitment to this program at all levels within DoD and through continuous communication of the requirements and successes to the community at large.

The long-term strategy for DoD corrosion prevention and mitigation includes a number of broad objectives that highlight the scope of the Department’s initiatives. Two that have the greatest potential are accelerating modernization and the closure of unneeded facilities. These two objectives are highlighted below. Other initiatives (such as establishing a corrosion information exchange network and increasing support for standards and product qualification) are discussed in Section III as subsets of specific DoD long-term strategy components.

Accelerate Modernization

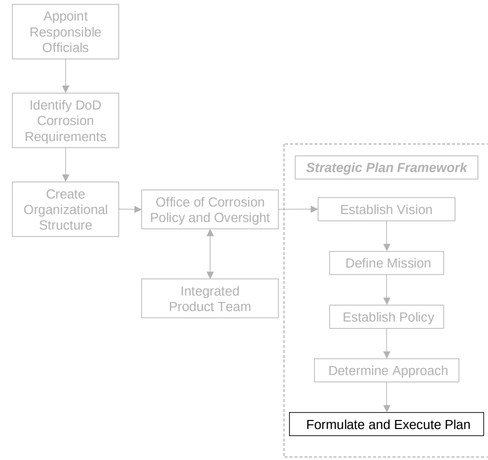
The most valuable action that DoD can accomplish to prevent or mitigate corrosion is to replace aging materiel assets more rapidly. This will allow the fastest introduction of planned-in-design corrosion mitigation features. The Department’s plan includes this approach as part of the overall effort to transform the military. The intent is to purchase new kinds of corrosion-resistant systems rather than acquire newer versions of older systems.

Close Unneeded Facilities

The Department is expending significant resources on corrosion control and maintenance of infrastructure that is no longer necessary. Corrosion mitigation costs are wasted when they are spent on facilities that are no longer required. Examples include tank farms or fuel distribution systems on unneeded bases. Periodically painting unnecessary stationary structures for corrosion control is also a drain on limited resources. Closing unneeded bases as part of the latest Base Closure and Realignment Act will reduce infrastructure expenditures and allow for funding of corrosion-related sustainment and modernization requirements at needed facilities.

Planning and Execution Processes

The following subsections summarize key elements of the DoD corrosion planning and execution processes.



Policy Direction

The Principal Deputy Under Secretary of Defense for Acquisition, Technology, and Logistics (PDUSD[AT&L]) and the Director for Corrosion Policy and Oversight will establish and publish policies regarding all aspects of corrosion prevention and mitigation. They will also assign responsibilities for policy implementation and direct the creation and performance of teams and working groups to act on policy directives and requirements as necessary.

Reporting

The Director for Corrosion Policy and Oversight and his staff will oversee the development of required reports to Congress and respond to GAO evaluations and reports. Working groups will be tasked to develop requirements, plans, and procedures that effectively respond to Congressional directives and GAO recommendations.

Near-Term Project Implementation

Each of the Military Services will identify corrosion prevention and mitigation projects that can be implemented immediately, and for which there is a high return on investment. Because projects must be funded by the Services for fiscal year 2004 starts, the PDUSD(AT&L) will encourage Military Departments to establish funding priorities for the most promising projects.

Requirements Development

The Services may identify specific requirements for corrosion prevention and mitigation technology or product development. These requirements will be prioritized and submitted to the CPCIPT for review and further action. The CPCIPT may assign review actions to an appropriate working IPT. The WIPT will review, evaluate, and recommend to the CPCIPT appropriate action on the submitted requirement. The WIPTs also may generate requirements and forward them to the CPCIPT for action and implementation.

Project Selection and Planning

Candidate projects for corrosion prevention and mitigation should be evaluated using the designated project evaluation template. For those projects deemed worthy of further consideration, the responsible program office must publish a project plan using the guidance provided in the template. Candidate projects will be forwarded to the CPCIPT for review and evaluation.

Roadmap Development

WIPTs will develop project roadmaps that reflect the objectives, actions, and milestones associated with their focus area. These project roadmaps will be integrated into an overall corrosion prevention and mitigation roadmap that reflects all IPT areas and project plans. The Corrosion Policy and Oversight staff will develop the overall program roadmap and integrate IPT areas and project roadmaps into an overall corrosion prevention and mitigation roadmap. WIPTs and the Corrosion Policy and Oversight staff will update and maintain their respective roadmaps.

Budgeting and Funding

The Corrosion Policy and Oversight staff will develop input to the Program Objective Memorandum and the Future Years Defense Program (FYDP) based on requirements and projects approved by the CPCIPT. The staff will develop budgets that allocate available corrosion prevention and mitigation funds to the Military Departments and other recipients for approved projects in order of priority. These budgets will reflect the project taxonomy contained in the program roadmap.

Management

Centralized policy direction and program oversight resides in the Office of Corrosion Policy and Oversight. Decentralized project management will be conducted in accordance with the policies and procedures of the Military Service or other performing organization. Participating organizations must vest decision-making powers with CPCIPT members from their organization. Successful management will depend upon continuous effective communication of status, requirements, problems, and results among all participating organizations.

Transition

Project managers must establish strong relationships with users of their products—prior to product transition. This should include written commitment from potential customers as well as transition plans. Other potential customers should be identified early in the project so the Military Department managers or the Office of Corrosion Policy and Oversight can plan added transitions.

Summary of Key Activities

The following is a chronology of key DoD corrosion prevention and mitigation activities since the passage of 10 U.S.C Section 2228.

Table II-1. Key Corrosion Prevention and Mitigation Activities

Month	Activity
December 2002	Section 1067, which enacted 10 U.S.C. 2228, requires specific DoD corrosion-related actions, including the submission of this report to Congress
January 2003	Establishment of DoD corrosion policy and oversight organization
May 2003	Submission of Interim Report to Congress Corrosion Forum I • Focus teams designated • Focus areas designated • Short- and long-term objectives established • Action plan initiated
July 2003	Corrosion Forum II • Draft policy documents drafted and reviewed • Performance measures drafted • *Defense Planning Guidance* (DPG) input reviewed
August 2003	Publication of Corrosion Project Plan template (for assessment of new projects) DoD corrosion website established
September–December 2003	DoD corrosion briefings presented to key forums (e.g., JCAA, NACE, and the Services)
September 2003	Corrosion Forum III • Metrics completed • Draft *DoD Corrosion Guidebook* (for new acquisition) reviewed • Final input to DPG reviewed for FYDP 2006–2010 • “Quick hits” for fiscal year 2004 identified and submitted • Specification or standards and qualification process reviewed and redefined
October 2003	Corrosion Prevention and Control IPT charter approved Established beneficial working relationship with NACE International CPC input provided to *5000 Final Guidebook* CPC input provided to DPG and Programming and Budgeting Activity
November 2003	DoD Corrosion Policy approved and promulgated DoD *CPC Planning Guidebook* completed (Spiral 1) AMPTIAC special corrosion issue published Tri-Service Corrosion Conference
December 2003	DoD *Long-Term Corrosion Strategy* report submitted to Congress

Note: AMPTIAC = Advanced Materials and Processes Technology Information Analysis Center; JCAA = Joint Council on Aging Aircraft; NACE = National Association of Corrosion Engineers.

Section III
Long-Term Strategy Components

The seven components of DoD's long-term corrosion strategy form the foundation of the Department's prevention and mitigation efforts. While these separate components cover the breadth and depth of corrosion initiatives and enable a compartmentalized focus by the WIPTs, they are interrelated and constitute the cohesive basis for both short- and long-term actions. This section describes the seven components, which are depicted in Figure III-1.

Figure III-1. Seven Components of DoD's Long-Term Corrosion Strategy

The Director for Corrosion Policy and Oversight identified, assessed, and coordinated DoD's ongoing corrosion prevention and control activities. Periodic reviews of the entire body of research, acquisition, and logistics programs also have been reenergized through conferences and symposia. There is increased coordination and information exchange among the Services, other applicable government and government-sponsored organizations (e.g., the United States Coast Guard, the National Aeronautics and Space Administration [NASA], the Federal Aviation Administration, and the Advanced Materials and Processes Technology Information Analysis Center [AMPTIAC]), and appropriate private-sector institutions (e.g., the National Association of Corrosion Engineers [NACE]).

The established processes for coordinating the Services' science and technology programs for corrosion prevention and mitigation will continue. In addition, the four policy and program areas within AT&L—Science and Technology, Installations and Environment, Logistics and Materiel Readiness, and Defense Systems—will remain accountable for the prevention and mitigation of corrosion in their areas and will support the Director's efforts separately. Further coordination and communication links are being established with each of the Military Departments regarding their materiel and infrastructure programs for corrosion prevention and mitigation.

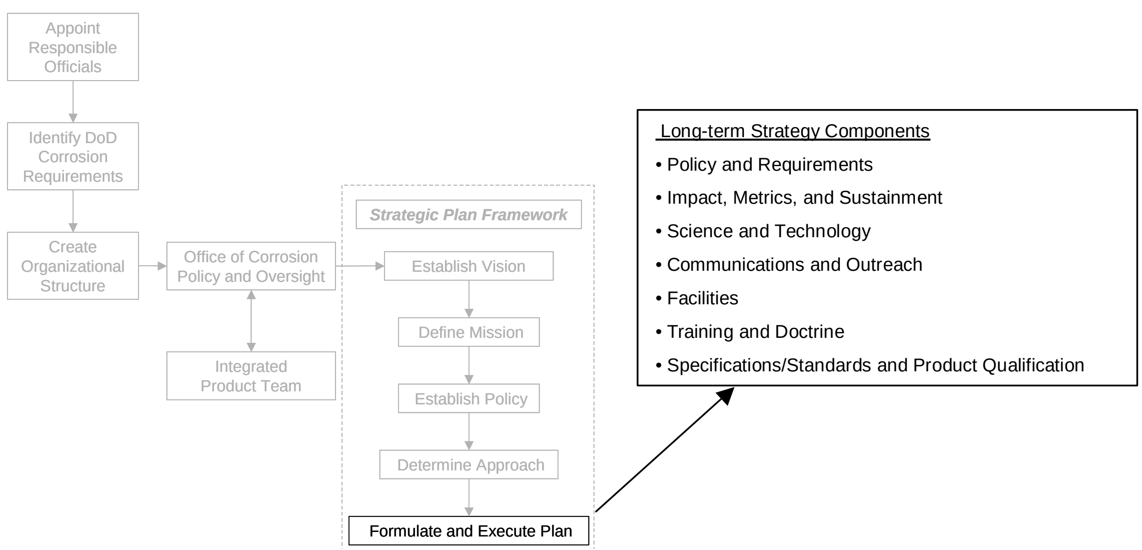
In addition to coordinating existing efforts, the Director initiated a number of specific actions, including planning and hosting a series of DoD corrosion forums and establishing the following nine corrosion-related focus groups:

- Policy
- Requirements
- Impact of Corrosion
- Common Problems
- Common Technologies
- Communication and Outreach
- Training and Doctrine
- Programs and Projects
- Specifications, Standards, and Qualification Process.

These nine focus groups were essential because corrosion is a complex problem with many stakeholders, not all of whom have fully compatible issues or objectives. The Director and focus group members identified the key stakeholders, who ranged from the operators of equipment and facilities back to those researching materials and corrosion mechanisms. These focus groups provided options and recommendations to improve the Department's already robust efforts. In particular, the focus groups were asked to ensure DoD does not overlook any common-sense approaches to alleviating corrosion and to ensure DoD can measure the improvement associated with any action. Several of the corrosion forums—including several off-site meetings designed to tackle each corrosion-related problem—were integral to the focus group machinery.

With their mission successfully accomplished, the nine focus groups have transitioned into the DoD Corrosion Prevention and Control Integrated Product Team (as the working IPTs described in Section I), which provides the expertise necessary to accomplish tasks in areas of concern to DoD (Figure III-2).

Figure III-2. Long-Term Strategy



The value of the WIPTs lies in their identifying required actions, completing actions that could be accomplished within the given timeframes, and identifying the resources and time necessary to complete pending action. Because of their value and the functionality of these areas, the following subsections highlight the activities for each long-term strategic component. The tasks are consolidated and summarized in Section IV.

Policy and Requirements

Policy

Long-term Strategy Components

- Policy and Requirements
- Impact, Metrics, and Sustainment
- Science and Technology
- Communications and Outreach
- Facilities
- Training and Doctrine
- Specifications/Standards and Product Qualification

Among the number of significant accomplishments in the policy arena, the most important is the publication of DoD corrosion prevention and control policy guidance, which includes the following:[1]

- The implementation of corrosion prevention and control planning as an explicit part of Performance-Based Acquisition as well as Performance-Based Logistics, as defined in DoD Directive 5000.1
- For programs subject to Defense Acquisition Board review, an assessment and evaluation of corrosion planning as a standard topic for the Integrating IPT, and the review of corrosion prevention and control planning by the Overarching IPT, with issues raised by exception to the DAB
- The inclusion of corrosion prevention and control in the *Designing and Assessing Supportability in DoD Weapons Systems Guidebook*
- The implementation of best business practices and best value decisions for corrosion prevention and control in systems and infrastructure acquisition, sustainment, and utilization.

A *Corrosion Prevention and Control Planning Guidebook* is being drafted to support these directions. A guide for facilities is also being drafted, and DoD is exploring the inclusion of corrosion planning as a standard requirement in the Defense Federal Acquisition Regulations and other DoD acquisition policy and guidance documents.

Because policy change will be a long-term, sustained effort, the DoD Corrosion Prevention and Control IPT has assumed responsibility for all policy issues. The following corrosion policy actions have been initiated by the CPCIPT:

- Policy memorandum—approved and published in November 2003
- Input to DoD 5000 documents
  - Reviewed draft guidebook
  - Policy language included in guidebook
  - Reviewed DoDD 5000.1 and DoDI 5000.2
  - Policy language included in DoDD 5000.1 for sustainment
- Input to *Defense Planning Guidance* (DPG)—Draft
- CPCIPT Charter—Charter approved and disseminated

[1] USD(AT&L) memorandum, *Corrosion Prevention and Control*, 12 November 2003, Appendix A.

- Policy language included in Designing and Assessing Supportability in *DoD Weapon Systems: A Guide to Increased Reliability and Reduced Logistics Footprint*
- Policy language included in *Corrosion Prevention and Control Planning Guidebook.*

Corrosion requirements have been included in *A Guide to Increased Reliability and Reduced Logistics Footprin*t in the following sections:

- Supportability Definition
- Access Requirements
- Design Guidance
- Selected Tasks for Maintainability and Supportability
- Technology Exploration and Reliability-Centered Maintenance
- Development of Total Life-Cycle Cost.

The revised acquisition policy directive specifically addresses corrosion prevention and mitigation in developing the program's life-cycle cost:

> Program managers shall develop and implement performance-based logistics strategies that optimize total system availability while minimizing cost and logistics footprint. Trade-off decisions involving cost, useful service, and effectiveness shall consider corrosion prevention and mitigation.

Adding corrosion effects to acquisition policy ensures financial decision-makers properly consider corrosion in life-cycle cost calculations and the total cost of ownership.

Requirements

The following are the principal requirements of DoD's corrosion prevention program:

- Define, collect, and assess programmatic and technology requirements.
- Define shortfalls, prioritize requirements and actions, assess life-cycle impact of unfunded support requirements, and recommend any new requirements.
- Develop corrosion roadmap.
- Evaluate changes in corrosion requirements dictated by new DoD philosophies and strategies.
- Consider future systems and forward operating environment effects on corrosion requirements.
- Create test protocols across the Military Services.
- Develop and track performance metrics of new materials and processes.

Near-term corrosion-related project requirements (through fiscal year 2004) have been identified. A total of 93 projects require funding from both operations and maintenance (O&M)

and research and development (R&D) accounts. Several examples of near-term projects are listed in Table III-1.

Table III-1. Examples of Fiscal Year 2004 Corrosion-Related Projects

Corrosion prevention compounds	Corrosion inhibiting lubricants
Shelters for aircraft and equipment	Controlled humidity preservations
Remote/real-time corrosion monitoring for pipes and tanks	Acoustic emission leak detection and corrosion assessment of pipe systems
Military vehicle washdown system	Corrosion service centers
High solids coatings for long-term corrosion prevention	

Near- and long-term corrosion-related funding requirements in support of DoD's equipment and facilities also have been identified. Project descriptions for military equipment and facilities funding are summarized in Table III-2.

Table III-2. Project Descriptions for Military Equipment and Facilities Funding

DoD military equipment	
Technical specification management	Maintains, updates, and develops (when necessary) critical corrosion specifications, standards, and qualified products lists in coordination with industry specification organizations for material process performance, quality, and improvements in corrosion control.
Resources for Corrosion Management Office (CMO)	GAO report 03-753 cites limited resources and reductions in personnel. The report also identifies the lack of formal program offices to direct policy recommendations and integrated Service strategic plans for implementing corrosion initiatives or including measurable, outcome-oriented objectives or performance standards. The CMO will also establish and monitor performance measures as required by Public Law. In addition, subject matter experts will provide the required expertise during acquisition program IPTs
Corrosion service centers	Provides comprehensive corrosion-related preventive maintenance in an on-base facility (avoiding transport to depot maintenance activities). Applies corrosion inhibited washing, preventive compound application, vapor-phase corrosion inhibitor, surface preparation, and anti-corrosive and chemical agent–resistant coatings.
Rinse facilities	System is designed to extend vehicle, equipment, and aircraft life by reducing maintenance man-hour expenditures thus increasing fleet readiness, and providing an added margin of crew safety.
Protected storage	Provides shelters and humidity-controlled protection for equipment stored outside. A previous research task showed reduction in corrosion by a factor of 65 from protected storage over uncovered storage.
Training	Provides training to technicians, program managers, and non-corrosion engineers on corrosion preventive compounds (CPCs). Training will include CPC plan development and documentation procedures, materials selection, standards, and processes consistent with updated technical orders, manuals, and bulletins.
Transition and implementation of technology	Develops and funds high-payoff activities with systemic, long-term benefits. This will bridge the gaps between civil and defense corrosion successes, and facilitate implementation of new technologies. Promising examples include application of improved corrosion-prevention compounds; corrosion sensors for fleet and tank monitoring; corrosion-inhibiting lubricants; inventory change of corrosion-prone alloys; composite electrical boxes; sanitary space preservation; and flight deck advanced non-skid materials.

Table III-2. Project Descriptions for Military Equipment and Facilities Funding

DoD facilities	
Corrosion surveys	Conduct base-wide corrosion control surveys at various locations. Facilities to be surveyed include waterfront structures, petroleum, oil, and lubricants (POL) storage and distribution facilities, including utility systems, pilings, bollards and piers, and other facilities identified during the survey. The surveys will also utilize the state-of-the-art nondestructive evaluation (NDE) technology, such as acoustic emissions leak detection and location technology.
Non-corrosive materials selection	Nonmetallic materials replace steel components in corrosive environments. DoD installations encounter problems with rusting exterior surfaces of components (such as steel doors, decking, and other components) often due to the use of deicing salts in the winter; corrosive industrial, below-grade moisture intrusion; or marine environments. Fiberglass reinforced polymer (FRP) is available as a non-corroding alternative to steel. Heat-resistant pavement materials for use in airfields will be investigated, along with heat-resistant joint sealants and high-performance pavement marking systems. Fly ash containing concrete will also be investigated. The performance of these materials will be evaluated and documented, and design guidance prepared.
Upgrade cathodic protection systems	Upgrade cathodic protection on POL tanks, water tanks, natural gas lines, and underground storage tanks. Upgrade and repair impressed current cathodic protection systems at all DoD facilities to include upgrading rectifiers, replacing/expanding anode beds, replacing isolating dielectrics and MOV lightning protection. This work includes implementation of innovative remote-monitoring technology for cathodic protection (CP) systems.
High-performance coating systems	High-performance coatings for steel in atmospheric and immersed exposure. New high performance coating formulations for steel have been developed but are not widely used. These coating formulations offer good ultraviolet resistance and retention of color and gloss. These coatings will be implemented on the exterior surfaces of steel water and fuel tanks.
High-performance non-hazardous corrosion inhibitors	Green chemical treatment for boilers and cooling towers. Develop low maintenance non-hazardous water treatment chemicals and smart monitoring and control systems to provide DoD installations and other communities with increased life, safety, and reliability for heating and cooling water systems, which are costly to operate because of biological growth, corrosion, and mineral scale.
Center of Expertise	Cathodic protection and paint technology experts at each of the Services will be available to provide onsite and in-house support for design and acceptance testing of CP and coating systems for DoD installations. The centers of expertise will also provide technical review of guide specifications and technical manuals as well as help prioritize research needs.
Training	Provides on-site training and workshops at DoD installations to introduce state-of-the-art technologies, specification and criteria update, and inspector certifications. Training and workshops conducted for non-inspector technicians, engineers, and program managers as well.

The Director for Corrosion Policy and Oversight has developed a project plan template to support the prioritization of corrosion-related projects. At a minimum these projects require technology, schedule, budget, benefits, return on investment (ROI), operational readiness, supportability, and maintainability information. The overall objective of the project plan is to assess candidate projects and actively support those with the greatest positive impact on corrosion elimination or mitigation.

Finally, the Director will coordinate with Service representatives to identify

- equipment being replaced or refurbished and
- on-going corrosion efforts and status.

Impact, Metrics, and Sustainment

Impact

Long-term Strategy Components
- Policy and Requirements
- Impact, Metrics, and Sustainment
- Science and Technology
- Communications and Outreach
- Facilities
- Training and Doctrine
- Specifications/Standards and Product Qualification

The following are among the objectives of the working IPT charged with discovering the impact of corrosion:

- Coordinate and consolidate the cost of corrosion data from all DoD components.
- Investigate specific cost data gaps and the necessary requirements to increase the fidelity of the information.
- Proliferate information on the impact of corrosion on safety, readiness, maintainability, weapon system life, reliability, and durability.
- Support the technical management of specifications and standards.
- Assist the Policy and Requirements WIPT in the identification of corrosion-related funding requirements.
- Establish methods to track effects of R&D products on corrosion mitigation and prevention.

Impact: Safety and Readiness

Corrosion undermines the physical integrity of structures and equipment, endangers personnel, and negatively affects mission accomplishment. For weapon systems or equipment, the GAO identified a number of examples related to safety and readiness impacts:[2]

- During the 1980s, several crashes of F-16 aircraft were traced to corroded electrical contacts that caused "uncommanded" fuel valve closures.
- F-14 and F-18 aircraft landing gear failures (collapses) during carrier operations were attributed to corrosion-related cracking.
- A 2001 study concluded corrective maintenance of corrosion-related faults had degraded the readiness of all of the Army's 2,450 force modernization helicopters.
- Corrosion has been identified as the reason for more than 50 percent of the maintenance needed on the Air Force's KC-135 aircraft.
- According to the Navy, corrosion maintenance for P-3C aircraft doubled in recent years.
- In 1996, the Army identified corrosion as the reason why 17 percent of its trucks in Hawaii were not mission capable.
- The USS *Kitty Hawk* returned from a series of deployments, including Operation Enduring Freedom, with significant maintenance problems, including topside corrosion.
- The 1999 delivery of a new Amphibious Combatant Ship with major coating defects cost millions of dollars to repair and delayed ship operations.

[2] United States General Accounting Office, *Opportunities to Reduce Corrosion Costs and Increase Readiness*, GAO-03-753, July 2003.

With respect to infrastructure, corrosion most often affects metal structures (such as bridges, steel-reinforced concrete, and pipelines) through a variety of mechanisms (such as galvanic action, microbial influence, stray current, or inappropriate materials selection). In 2001, DoD reported that more than two-thirds of its metal structures or infrastructure were in such poor condition that they were unable to meet certain mission requirements. (Corrosion was identified as a major contributing factor.)

Impact: Cost

Corrosion negatively impacts cost in a number of ways. It can reduce the performance quality of warfighting equipment, which may in turn generate the need for additional operational assets and resources. With the potential for corrosion, considerable downtime is required to detect and assess the presence of corrosion and its impending effects on this equipment. When corrosion is treated, the equipment requires additional downtime for maintenance. This reduced availability of equipment significantly affects readiness. To compensate for reduced readiness, the Services procure additional equipment at a considerable cost. So the cost effects multiply—added operations, increased maintenance labor and spare parts, more repair equipment, and added warfighting equipment inventories contribute to increased cost and create the potential for even more corrosion and its effects.

The cost of corrosion on operational safety can be immeasurable in terms of injury or death. While the impact of corrosion on physical infrastructure may not be as severe, reduced infrastructure readiness and safety affects cost considerably; unfortunately, it is difficult for DoD to accurately quantify these multiple costs. Despite this difficulty, determining the financial cost of corrosion is an essential component of the Department's prevention and mitigation strategy.

To quantify improvement—an indispensable metric—an accepted baseline must be established. In addition, reliable corrosion cost estimates are necessary to identify areas that require aggressive action and to justify the expenditure of resources for prevention and mitigation projects.

Previous studies have provided estimates in the range of $10 billion to $20 billion annually. For example, the GAO report on corrosion reported[3]

> …in 2001, a 2-year, government-sponsored study estimated the direct costs of corrosion for military systems and infrastructure at approximately $20 billion annually and found corrosion to be one of the largest components of life-cycle costs for military weapon systems. Another study puts the cost at closer to $10 billion…the Army estimated in 1998 that approximately $4 billion was spent on corrosion repair of helicopters alone.

Within the DoD Corrosion Forum structure, the Impact of Corrosion focus group identified and consolidated existing Service cost-of-corrosion estimates. Several of the Service components had captured corrosion costs for many (but not all) of their assets, and nearly all of the Services identified how these numbers can be obtained. The focus group's rough (and partial) estimate was within the same $10 billion to $20 billon cost of corrosion range identified above.

An in-depth study to identify and assess the Department's cost of corrosion—using a DoD-wide methodology—is of critical importance and is a top resource priority for the Director of

[3] Ibid., GAO-03-753, page 3.

Corrosion Policy and Oversight. Logical study steps would build upon the efforts of the Impact of Corrosion focus group and would include the following:

- Identify the Services' existing corrosion documentation requirements.
  - A 2001 Army study found that no single data system provides aggregate corrosion data about the cost, maintenance, and readiness, and that the existence of many separate databases restricts the ability to collect standardized data reflecting consistent characteristics.
  - Navy officials stated that information regarding the cost of corrosion is incomplete because these costs are difficult to isolate from overall maintenance costs.
  - Facilities officials at Camp Pendleton said their databases do not specifically identify data as corrosion-related.
- Develop an approved DoD corrosion cost approach that is acceptable to all Services. It is important to be able to address the costs by platform type (air, land, sea, facilities, etc.), because all Services have platforms in these categories, and the technology tends to be common.
- Populate a cost-approach template with available data. If data is not available, use estimates or data sampling from representative units and organizations.
- Refine the methodology to identify and assess the Department's cost of corrosion (as needed) and update corrosion costs annually.

Knowing the cost of corrosion is essential to adequately implement DoD's long-term corrosion prevention and mitigation strategy. As such, identifying and assessing the cost of corrosion has priority, contingent upon available funding.

Metrics

To effectively monitor corrosion activities at the enterprise level, measurements must allow the assessment of a number of areas, including policy, resources, technology, and communication and outreach.

One of the chartered working IPTs is addressing the need for metrics and how to estimate the investment necessary to prevent and control corrosion. While this is a challenging task, the Services have experience determining and analyzing science and technology and acquisition investments. DoD will focus on coordinating the efforts and refining the investment and payoff analytic capabilities that relate to corrosion prevention and control programs.

DoD's Corrosion Executive continually challenges all appropriate corrosion personnel to define realistic metrics that can be assessed as part of normal DoD operations. Data will not be collected just for data's sake, however; data will be collected to help the Department learn what works so that it can be more effective in corrosion mitigation.

DoD considers two factors of corrosion measurement.

- The first pertains to the effects of corrosion: What is the cost of corrosion in terms of performance, availability, and resource consumption?
- The second pertains to measuring the payoff from corrosion prevention and control efforts: What is the improvement in performance, availability, and resource consumption?

The Metrics WIPT is addressing both of these factors. The methodology for measuring the different aspects should be similar and closely associated, because DoD must measure conditions before and after corrosion mitigation actions in order to gauge the extent of improvement. DoD also expects that the most revealing metrics (at the macro level) will be related to system availability and total ownership cost.

An initial core set of corrosion-related metrics has been developed and is depicted in Table III-3. These should allow the OSD and Service leaders to assess progress in meeting the agreed-upon corrosion objectives. There is flexibility to modify this metrics set to meet new or evolving corrosion-related objectives.

Table III-3. Initial Core Set of Corrosion-Related Metrics

Objective	Metric
Short term	
Policy guidance covering all pertinent systems and infrastructure is promulgated and is current and effective.	Narrative assessment. 10 U.S.C. Section 2228(b)(2).
Director, Defense Corrosion Policy and Oversight, ensures funding levels remain at or above the fiscal year 2006 level (in constant dollars).	Narrative assessment to include budget year funding as percentage of baseline. 10 U.S.C. Section 2228(b)(3).
Monitor compliance with policy that corrosion prevention technologies and treatments are fully coordinated, considered, and incorporated into all major defense acquisition programs and infrastructure projects.	Narrative assessment. 10 U.S.C. Section 2228(b)(4) and (5).
Reviewed and validated information on proven methods and products relating to corrosion prevention of military equipment and infrastructure are available on a central DoD World Wide Web location.	Breadth and currency of information; number of visits to website. 10 U.S.C. Section 2228(c)(2)(C).
Long term	
Achieve returns on investment for Services' projects.	Validate all ROI as soon as projects are implemented.
Reduce corrosion costs.	Each Military Service will submit corrosion cost reduction status reports for all projects implemented.
Minimize the number of hours of corrosion-related work on military equipment.	Initially a narrative assessment. Will transition to a quantifiable metric if it can be determined that a labor-hour baseline can be established and factors that directly influence corrosion labor hours are identified.
Optimize corrosion prevention and mitigation efforts through training.	Training modules on proper applications and techniques of corrosion compounds, sealants, and coatings are available, are current, and are attended on an annual basis by 100 percent of maintenance personnel charged with corrosion prevention and mitigation.
Maximize safety in the workspace.	Reduce the number of incidents of injury to personnel due to effects of corrosion.

Sustainment

The majority of the Department's planned corrosion prevention and mitigation actions will benefit currently fielded equipment and infrastructure. The remaining actions, such as revisions to acquisition regulations, will benefit new equipment once it is fielded.

The sustainment component of DoD's long-term strategy is linked to each of the other components (e.g., policy and requirements, science and technology, communications and outreach, and training and doctrine). Designating sustainment as a distinct long-term strategy component ensures the coordination with the other components that is required to meet the objective of a rapid reduction in the effects of corrosion for fielded systems.

In addition, the continuing support of the Joint Council on Aging Aircraft (JCAA) will greatly assist the Department's corrosion prevention and mitigation efforts—particularly in regard to existing equipment.

A key element of this approach is to identify and correct problems quickly. The current focus is on technology insertion and identification of "project quick lists" for fiscal year 2004 and 2005 funding. Table III-4 lists selected projects that have been identified by the Services, and reviewed by the Director of Corrosion Policy and Oversight, for this sustainment-related funding.

Table III-4. Sustainment-Related Priority Projects

Army
Corrosion prevention technology (CPT) for aviation
Corrosion prevention technology applications
Aviation corrosion repair kits
Controlled humidity preservation (operation protection and storage)
Navy
High-strength steel coating repair
Baseline assessment of specifications and qualified products list
MIL-L-87177 coating for corrosion protection of electrical connectors
AvDec gaskets for electrical and floorboard applications
High solids, edge-retentive shipboard paints
Composite electrical boxes and ship stanchions
Shipboard sanitary space preservation
Shipboard tank and void preservation
Wireless shipboard tank sensors
Air Force
AvDec products (gaskets, sealants, tape) for C-130 depot maintenance applications
Revised/improved specifications for CPCs
Improved avionics reliability through the use of corrosion-inhibiting lubricants
Shelters for aircraft and equipment
Cumulative environmental exposure sensors for fleet monitoring and corrosion management

Table III-4. Sustainment-Related Priority Projects

Marine Corps
Military vehicle washdown system
Corrosion service centers
Protected storage—equipment for Marine Expeditionary Forces
Infrastructure
Corrosion control training, various locations
Facility corrosion control surveys
In-situ pipe coating system for mitigation of corrosion
Remote and real-time corrosion monitoring for pipes and water tanks
Concrete repair technologies
DoD facilities corrosion control centers
Alkali silicate reaction inspection of airfield pavements
Update corrosion control websites
CHP and distribution system corrosion control, various activities
Acoustic emission leak detection and corrosion assessment of pipe systems
Coatings studies
Repair CP system deficiencies and optimize backfill for buried structures, various activities
Critical electrical power systems require a grounding system

Science and Technology

Science and technology (S&T) is a critical component of the Department's long-term strategy. As such, significant activity is already underway. The following are examples of current efforts.

Army, Tank-Automotive Research and Development Engineering Center

Overview

The Tank-Automotive Research and Development Engineering Center (TARDEC) is beginning to address the continuing problem of high in-service damage associated with the standard engine-compartment hood on the High Mobility Multipurpose Wheeled Vehicle (HMMWV). Forty-six of the new composites resin infusion molding process hoods have been fabricated and are undergoing a 12-month field evaluation. Corrosion is among the leading reasons for significant annual sheet metal spare- and repair-parts acquisitions. This program is unique in the Army: It directly addresses the cause of the corrosion "sustainment" problem by replacing steel with organic composites.

Major Goals, Objectives, and Metrics

- Increase long-term durability of composite replacement parts by a minimum increase of 25 percent fatigue life.
- Eliminate corrosion.
- Reduce acoustic signatures by 25 percent.

Recent Accomplishments

Design and analysis of the replacement hood were completed, two candidate designs were fabricated and tested under loadings that simulated a soldier jumping onto the hood, impact loads of brush on the front corners, and a front-end impact. Results of finite-element simulations using LS-DYNA, a quasi-static simulated crash loading (via laboratory testing) of the component, and a 35-mph crash of a hood mounted on a HMMWV were compared and agreed so well that final design detail changes were approved without additional crash testing. As part of the program, each new component will undergo testing and validation, including field trials on military vehicles. The final step in the process is development of a technical data package (TDP) for the component for approval within the Army via the Engineering Change Process. This will allow Army procurement to purchase these replacement components for widespread use in the wheeled vehicle fleet.

Under the Composite Body Parts Program, "hoods" continue to be addressed, with the next one being for the M35A3 (2.5 ton) truck. The A3 modifications "under the hood" required the current sheet metal hood to be split down the center and a metal splice pop-riveted in. Success in this application will emplace and qualify a spare parts "source" for this hood; the Army currently has none to support the 5000-truck fleet worldwide. Other technologies under investigation as part of these projects include the Diaphorm™ process, flexible tooling workcell, and recastable ceramic tooling.

Army, Industrial Ecology Center, Tank-Automotive Research, Development, and Engineering Center, Pacific Rim Corrosion Research Program

Overview

The major thrust of the Pacific Rim Corrosion Research Program (PRCRP) is to conduct research to better address corrosion issues for the U.S. Army in the Pacific Theater of Operations (PTO). These include a wide array of climactic conditions experienced in the Korean peninsula, Australia, Hawaiian Islands, Alaska, and the Pacific Coast. Through research, corrosion mechanisms will be identified and results correlated with that of the actual PTO climate. Corrosion samples will be tested both in actual atmospheric conditions and in the corrosion laboratories to study effects on several materials such as metal-matrix composites, ceramic film coatings, and micro-electromechanical systems (MEMS). There will be focus on identifying corrosion mechanisms, methods of corrosion protection and inhibition, and development of corrosion test protocols relevant to the PTO. Elements of the Army Industrial Ecology Center, Tank-Automotive Research Development, and Engineering (RD&E) Center, Army Research Laboratory, and the U.S. Army Pacific Command will team together with the University of Hawaii, Manoa, (UHM) and industry to play a major role to assure goals are met if not exceeded.

Major Goals, Objectives, and Metrics

The PRCRP has two main goals—to address current corrosion prevention requirements for existing equipment and secondly, to have designed-in corrosion resistance for future systems being developed under Army transformation. In particular, to tackle short-term concerns, PRCRP will test and evaluate commercial corrosion inhibitors for use on a variety of existing Army equipment. These tests will be based on joint test protocols (JTPs) developed under the Army Corrosion Measurement and Control (CMC) Program. For the future systems, the Army will require lighter, stronger materials for equipment, vehicles, aircraft, ammunition, and weapons platforms, and will seek to employ a variety of new materials. Therefore corrosion behavior and prevention solutions will be sought for materials such as ceramic, metal-matrix composites, metal alloys, and their compatibilities. In addition, the Army will utilize smart and precision weapons that will require use of microelectronics in a variety of applications.

Recent Accomplishments

In August, the first in-process review of the PRCRP was held at the UHM College of Mechanical Engineering. Each research subtask was presented along with a laboratory tour. In addition, site visits to the atmospheric corrosion test yards took place on the island of Oahu. User military sites, such as Schofield Barracks and Wheeler Army Airfield, were also visited. Finally, a meeting was held with the DoD Corrosion Science Advisor representatives to discuss mutual interests and to introduce the PRCRP.

Army, Industrial Ecology Center, Tank-Automotive Research, Development, and Engineering Center, Component Science and Technology Program

Overview

This program is intended to demonstrate technologies for the prevention/minimization of the effects of material degradation on Army materiel so that these technologies can be introduced into weapon system design, the industrial base, or depot maintenance. The program will include tasks that capture the life-cycle cost of material degradation to Army materiel so that return on investment of implementation of new technologies can be made. The Army corrosion website will be expanded and maintained as part of this effort. The website was developed under the Army's Corrosion Measurement and Control Program. This strategy will support the U.S. Army Materiel Command (AMC) CPC Program Plan (1 March 2001) as a process for developing, testing, and implementing new technologies to mitigate material degradation and thereby enhance readiness and reduce life-cycle costs.

Major Goals, Objectives, and Metrics

- Develop Army corrosion website which will include corrosion data repository, approved JTPs, list of products which have successfully met JTP requirements and training modules for application of corrosion inhibitor products and techniques.
- Demonstration of handheld data collection tool for collection of corrosion data on vehicles and helicopters. Tool will be used to facilitate the upload of data to the Army corrosion website and will aid in the determination of ROI for implemented technologies.
- Develop and approve JTPs for the testing of products for the inhibition of corrosion on asset classes. Establish testing capability to test products/processes against approved JTPs.
- Assess nondestructive testing (NDT) technologies for the detection of hidden corrosion under paint/coatings. Develop test methodology for the validation/qualification of NDT technologies.
- Determine the mechanisms by which sprayed-on corrosion inhibitors provide protection to surfaces such that these formulations can be optimized.
- Demonstrate a portable technology for the application of corrosion inhibitors.

Recent Accomplishments

- Automated process for the application of corrosion inhibitors has been designed and demonstrated. Process optimization is currently ongoing. The automated process uses less material and is only 34 percent of the cost as compared to the manual process.
- Economic models for the determination of the cost impact of corrosion have been developed. The Army's Cost and Economic Analysis Center is currently being solicited for validation of these models.

- A handheld data collection tool has been developed. Handhelds are being used in conjunction with corrosion service centers for data collection and determination of ROIs for implementation of new technologies.
- Numerous JTPs have been developed and are currently in editing and staffing.
- Assessment of the potential impact of corrosion on MEMS devices and microelectronics has been completed. This study demonstrated that at the present time, little consideration is being given to the impact of corrosion on these devices.
- An assessment of pertinent NDT technologies has been completed.
- A study of the efficacy of sacrificial metal macro coats is currently ongoing. The study includes numerous alloy compositions and deposition methodologies.

Army, Aviation and Missile Research, Development, and Engineering Center

Overview

This is an effort to evaluate Carwell AR-500 corrosion preventive compound for use of Army aviation assets.

Major Goals, Objectives, and Metrics

The major goal is to complete airworthiness testing of Carwell AR-500 in order to determine if it is acceptable to apply to Army aviation components. The follow-on step will be to identify the components for possible application in order to provide potential reductions in corrosion maintenance.

Recent Accomplishments

Air-worthiness testing is scheduled to be completed during the first quarter of fiscal year 2004.

Army, U.S. Army Research Laboratory

Overview

A current effort is focused on delivering a "coating system from pretreatment to topcoat" that supports environmental compliance, durability, and survivability, including both camouflage properties and chemical warfare resistance. These three guiding principles of environmental compliance, durability, and survivability guide and direct all coatings and corrosion efforts. The efforts of the U.S. Army Research Laboratory (ARL) have been directed toward environmental compliance and survivability.

Major Goals, Objectives, and Metrics

Develop coatings that meet current camouflage and chemical agent resistance requirements, and provide a minimum of 5-year coating life without rework.

Recent Accomplishments

- Development and implementation of water dispersible CARC MIL-DTL-64159 with enhanced durability, zero HAP, and low volatile organic compounds (VOCs).
- Publication of MIL-DTL-53072 Application CARC document that provides details for proper application procedures.
- MIL-DTL-11195 zero HAP corrosion-resistant coatings for large and medium caliber ammunition.

Army Corps of Engineers, Engineer Research and Development Center

Overview

The Engineer Research and Development Center (ERDC) conducted research to address facilities-related corrosion since the late 1970s. The primary focus has been the development of technology to mitigate corrosion on metallic components such as buried pipelines, storage tanks, heating and cooling equipment, and metallic building systems. The areas of interest include high performance coatings, cathodic protection, corrosion inhibitors, and materials selection. The service environments include soil-side corrosion and atmospheric, salt water, and fresh water exposure.

Major Goals, Objectives and Metrics

- Increase the lifespan of facility components at an affordable cost
- Decrease the life-cycle cost for facility components
- Mitigate corrosion on metallic components.

Recent Accomplishments

The following technologies have been developed under various research programs.

Ceramic Anode

Historically, two materials—silicon-iron and graphite—have been used in the cathodic-protection anode. These materials, however, are brittle and have high consumption rates. The ERDC Construction Engineering Research Laboratory (CERL) developed a breakthrough cathodic protection, the ceramic-coated anode. The ceramic anode makes corrosion protection available at one-half the life cycle cost of previous technologies and with a size reduction that permits installation in areas previously considered too small. Additionally, the consumption rate is significantly lower and the ceramic-coated anode is resistant to mechanical damage. These factors significantly increase the cathodic protection system reliability from an average of 20 percent to a potential 90 percent by using ceramic anodes.

Heat Exchanger Coatings

ERDC-CERL has developed baked-on phenolic coatings for use on the water-side of copper U-tube bundles to prevent scaling and corrosion induced failures. When the coatings are applied to copper tube heat exchanger bundles, the maximum reduction in heat transfer efficiency is approximately 5 percent over the life of the coatings. This outweighs the 60 percent heat transfer reduction associated with a 0.008-inch thick scale deposit after 90 days of operation. The coating greatly reduces maintenance and repair costs for installations with corrosion and/or scaling problems associated with heat exchangers.

EOP

Electro-osmotic pulse (EOP) technology offers an alternative to the trench-and-drain approach by mitigating water-related problems from the interior (negative side) of affected areas without the cost of excavation. In basic terms, the EOP system uses pulses of electricity to reverse the flow of water seepage, actually causing moisture to flow out of the basement walls, away from the building. The technology works by alternately pulsing a direct current field with an "off" period. This electrical pulse causes cations (e.g., Ca++) and associated water molecules to move from the dry side (anode) towards the wet side (cathode) against the direction of flow induced by the hydraulic gradient, thus preventing water penetration through concrete structures. EOP excels in its ease of installation compared to conventional waterproofing methods and provides a significant improvement in air quality as a direct result of correcting active water intrusion.

Acoustic Leak Detection

ERDC-CERL co-developed acoustic emission leak detection technology to accurately locate and estimate the size of leaks. The acoustic instrument operates at 15,000 Hz and uses coincidence detection to locate leaks. The benefit of this instrument is its operation in the presence of flow noise and noise caused by vehicular traffic on roads near monitored pipes. The system is capable of detecting leaks as small as 0.1 gallon per hour. Implementation of this technique is rapid: it takes only approximately 1 hour to investigate 1 mile of pipeline. This technology pinpoints leaks for a small fraction of the excavation used in the conventional approach.

Coatings

The Corps of Engineers (COE) uses thermal-sprayed zinc and aluminum coatings on hydraulic structures exposed to severe impact and abrasion damage caused by ice and floating debris. An experimental study of the twin-wire electric arc (TWEA) spraying of zinc and aluminum coatings was conducted to demonstrate the suitability of this technology for Army applications. Experiments on six materials systems were conducted using classical and statistically designed fractional-factorial schemes. The coatings were characterized with bond strength and deposition efficiency tests, and optical metallography. Coating properties were quantified with respect to roughness, hardness, porosity, oxide content, bond strength, and microstructure. Coating performance was evaluated and quantified with erosion testing, and a parameter-property-performance relationship was developed for each materials system.

Remote Monitoring for Cathodic Protection

CP systems for water storage tanks must be periodically tested in order to ensure proper performance. Remote monitoring units (RMUs) provide the ability to monitor CP system performance data from remote locations using modem-equipped personal computers. RMUs allow continuous monitoring of CP systems from a central location and will provide personnel with immediate warning of potential corrosion hazards. Based on the successfully testing of RMUs for water tanks at Fort Hood, ERDC-CERL is in the process of implementing this technology at two similar water tanks at Fort Carson. By implementing remote monitoring for cathodic protection, the life of each tank is expected to be extended by 20 years.

Smart Water Treatment

The current state of corrosion and water chemistry control in utility systems (heating, cooling, and potable water production and distribution) for the Army relies on a combination of online and manual analytical procedures that are used as a basis for adjusting treatment and control in those systems. Typically, control of blowdown and chemical treatment rely on the results of grab samples collected and analyzed by a technician on a predetermined schedule. The frequency of testing of the various systems and the technical skills possessed by the individual performing the tests are critical. ERDC-CERL has co-developed an alternative technology that provides an active, low maintenance, self-diagnosing and self-adjusting corrosion control system for building heating, cooling, and potable water piping systems. In addition, green chemicals are being utilized to reduce the environmental impact of water treatment. Following are specific benefits:

- Reduces manpower for system monitoring and control of corrosion/scale
- Increases life-cycle of building components
  - Heating systems increase from 10 to 25 years
  - Cooling systems increase from 5 to 10 years
  - Plumbing systems increase to 75 years
- Reduces use of environmentally sensitive chemicals
- One percent improvement in Army utility O&M performance could save $18 million annually.

Materials Selection for Highly Corrosive Environments

Wastewater treatment facility components generally experience both atmospheric and immersion corrosion. The corrosion intensive components include buried piping, handrails, gratings, ladders, electrical junction boxes, clarifier rake arms, and concrete walls. Hydrogen sulfide, which is usually present, has wide-ranging effects in wastewater systems, most notably causing corrosion and odor problems. Judicious selection of new corrosion-resistant coatings and alternative materials, and implementation of cathodic protection for tank and machinery components can provide the needed corrosion protection. The benefits of the implementing corrosion control technologies at the wastewater treatment plants are restoration of the plant to optimum operating condition, reduced maintenance, and increased safety. Implementing proper materials selection is expected to extend the life of a plant by 20 years.

Navy, Naval Surface Warfare Center Carderock Division

Overview

The Navy requires an improved shaft coating system to help achieve a 12-year docking cycle while reducing shaft life-cycle costs. The objective is to develop an improved composite protection layer for ship main propulsion shafts that will afford corrosion protection for 12 years.

Major Goals, Objectives, and Metrics

Replace current 7-year docking cycle with 12-year docking cycle, while reducing shaft life-cycle costs.

Recent Accomplishments

Improved anticorrosion coating formulation developed. The coating is currently undergoing peel testing and environmental conditioning.

Navy, Office of Naval Research

Overview

The U.S. Navy and Marine Corps operate in extremely aggressive seawater-laden environments where corrosion becomes a serious issue. Maintenance required to combat corrosion represents a major cost driver for the Navy, and one that continues to grow as the fleet ages. In the struggle to preserve capability, sailors and Marines spend a tremendous amount of time in corrosion control, inspection, and/or repair of damage caused by corrosion. One result is less time spent on training for their primary mission as warfighters. The impact is clearly reflected in the substantial increase in life-cycle costs of naval platforms and assets and the declining personnel retention rate.

Navy S&T provides a full spectrum of basic and applied R&D to advanced technology demonstration and implementation. The Materials S&T Division at the Office of Naval Research (ONR) fosters scientific research in corrosion and corrosion related maintenance reduction technologies for ships, aircraft, land-based vehicles, and waterfront facilities. In order to address the issue of corrosion prevention and control, ONR sponsors research and development ranging from fundamental mechanistic studies to product demonstrations in the field. ONR S&T focuses on concept exploration of mechanistic corrosion processes, development of corrosion-resistant alloys and coatings, development and application of environmentally benign surface modifications, and sensing technologies to detect the onset of corrosion or inspection of the impact of corrosion.

These efforts will lead to reducing total ownership costs in the Navy and Marine Corps with insertion of new and advanced materials or corrosion control technology during design, construction, and service of Naval and Marine Corps systems. This will also enhance naval capabilities by fulfilling Navy and Marine Corps Strategy for Seapower 21 for the current Navy, the Next Navy, and the Navy after Next.

Objectives

Explore concepts and research and develop corrosion science and technology in the areas of materials, surface modification, processes and sensing/detection to meet naval requirements, enhance naval capabilities and reduce total ownership cost of naval assets during design, construction, and service through corrosion/maintenance reduction technologies.

Major Goals

The major ONR goals for corrosion/maintenance reduction include the following:

- Fundamental research on corrosion mechanisms/processes
  - Investigate/understand mechanisms for initiation and propagation of corrosion in materials, which, in turn, can lead to introduction of mitigation technologies.
  - Improve materials performance through superior passivation by the use of surface treatments, inhibitors, or alloying.
  - Investigate the seawater environment and factors leading to corrosion initiation or corrosion control through the influence of microorganisms.
- Coatings and alloys resistant to seawater and/or marine atmosphere
  - Develop organic coatings that have low VOCs, are environmentally compliant, and provide increased service life.
  - Develop inorganic coatings that provide comparable or improved performance over the hazardous materials, such as chromium (VI) used in chromates or cadmium used for sacrificial metallic coating.
  - Develop new coating materials and processes that extend service life
- Develop surface modification technologies that provide improved capability for preservation, repair, and elimination of corrosion while reducing life-cycle cost and required manpower
- Develop sensing technologies that provide capability for corrosion detection, monitoring, and inspection, and enable condition-based maintenance.
- Investigate and develop technologies that mitigate corrosion and/or environmental cracking inherent in selected materials or generated by fabrication processes.
- Develop corrosion phenomena modeling to predict corrosion behavior/process or to mitigate corrosion propagation.

Metrics

The success of the Navy's S&T corrosion program is measured by a number of metrics:

- Exit criteria
- Technology level readiness (TLR)
- Transition of the products to the fleet
- Insertion of the products to
  - legacy systems and
  - acquisition phases of various programs for new platforms or weapons systems.

The quantifiable measure being employed is cost avoidance, represented as NPV (net present value) over the life cycle of the system after implementation of the technology.

Recent Accomplishments

- Completed ship tank coating demonstrations using developed polyurethane-based, rapid-cure coating systems—four ballast tanks and one damage control (DC) void.
- Delivered a near-product-level C2MS system that contains bolt head and environmental sensors and data acquisition unit (DCU)—Flight test on H-60 starts in December 2003.
- Completed a test bed design for MHP, module design, and test and evaluation master plan.
- Demonstrated a prototype NDI system that integrated a pulse thermography and spectral imaging technology into one system.
- Demonstrated trivalent chromium and conductive polymer as replacement for hexavalent chromium conversion coatings.
- Demonstrated a generic coating system for use on advanced non-magnetic stainless steel double hull.
- Discovered nickel (Ni)-based alloys with an order of magnitude improvement in high-temperature corrosion resistance.
- Identified the mechanism by which alumina-forming alloys and coatings spall by water vapor at high temperature.
- Developed cadium (Cd)-free sacrificial protective coatings based on zinc-nickel–based ternary alloys with enhanced properties over Cd.

Navy, Naval Air Systems Command

Overview

Navy and Marine aircraft corrosion costs the Navy an estimated $1 billion a year, with the maintenance burden increasing as aircraft continue to age beyond their original planned life. Corrosion of Navy aircraft is exacerbated by a number of compounding factors, foremost being the harsh operating environment:

- At sea for long periods of time on aircraft carriers
- High operational tempo, which makes performing proper corrosion maintenance difficult
- Challenging chloride, sulfate, and other corrosion species in combination
- A powerful and pervasive electro-magnetic environment
- Strict environmental constraints that discourage many protective products.

The second greatest challenge relates to aging aircraft and their impact on sustainment and readiness. The Navy's fleet of aircraft is approaching an average age of 20 years, the oldest in Naval history. Accordingly, the required levels of maintenance for these aircraft are rising. This trend will continue for at least the next 10 years, putting tremendous pressures on the aviation operations and maintenance budget of the Navy.

Major Goals, Objectives, and Metrics

The following are the major goals of the Naval Air Systems Commands NAVAIR) for corrosion prevention efforts:

- Reduce impact of corrosion on aviation systems (safety, reliability, etc.)
- Decrease maintenance costs
- Improve readiness and mission capability
- Support Joint coordinated technology efforts and road maps.

The objectives of NAVAIR's corrosion-related activities are to validate and implement new corrosion technologies, improve corrosion training and information dissemination, and to pursue environmentally friendly materials and processes that perform as well as or better than current corrosion protection materials while targeting similar or lower costs. Metrics include reduced maintenance man-hours for processes, decreased maintenance costs, improved readiness, and mission capability.

Recent Accomplishments

The following are a few examples of NAVAIR general accomplishments and some technology specific efforts:

- The Corrosion Fleet Focus Team (CFFT) was established under NAVAIR's Aging Aircraft Integrated Product Team (AAIPT), and consists of a network of corrosion experts from geographically dispersed NAVAIR sites and the fleet, whose role is to combat corrosion across the aviation fleet. The CFFT's focus is on operations and maintenance based projects aimed at validating and implementing new corrosion prevention and control technologies, including advanced coatings and processes, sealants, corrosion preventative compounds, composite and metal repair, adhesive bonding, and prognostics and diagnostics. The team is designed to address corrosion problems that are cross-platform and to facilitate rapid assessment and implementation of common solutions. Because the team is comprises acquisition, research and development, in-service engineering, and fleet personnel, implemented technologies will reflect the best value to the fleet and significantly reduce operations and support costs for the Navy.
- Recently, radial bristle discs for the removal of coatings and corrosion products were developed and evaluated by the NAVAIR under the CFFT. The positive results on aluminum and high-strength steel were rapidly documented in NAVAIR's *Corrosion Control Manual*, and implemented in the fleet. Information on the performance of the discs had been distributed to the community and the discs are currently being evaluated for use on other substrates including titanium, magnesium, and composites.
- A new cleaning pad, which incorporates a rubberized surface to aid in the efficiency of cleaning low gloss paint systems, was evaluated and has shown dramatic improvements in surface cleaning performance while at the same time decreasing overall process time. Implementation of this technology will allow for significant savings in fleet maintenance man-hours and cost during routine maintenance operations. The deployment requirements and associated technical manual changes have been developed and an interim rapid action

change (IRAC #29) to the NAVAIR 01-1A-509, *Cleaning and Corrosion Control Manual*, has been released.

- Fleet-level paint touch-up is the target for the new Pre-Val® Sprayers. This technology has been evaluated with the goal of enabling the spray application of high-performance multiple-component coatings in touch-up procedures. Approximately 70 topcoat colors and 9 primers from 4 different manufacturers are available through the General Services Administration (GSA). National stock numbers (NSNs) have been assigned for these products and the procedures, warnings, and cautions for the technical manual change have been released in IRAC #27. Future efforts will be looking into additional coatings that could be used with this application technology and improved spraying capabilities.
- The strategy, planning, and development for corrosion preventive compounds is underway using Joint Service cooperation. Through the Corrosion Steering Group of the Joint Council on Aging Aircraft, a joint CPC roadmap has been completed. The Air Force, Army, Coast Guard, and Navy are coordinating their activities in the development and testing of newly developed, commercially available CPCs. This is leading to tremendous leveraging of resources, with such benefits as a greatly reduced overlap of tests, and the modernizing of multiple CPC specifications to best meet the needs of all participating organizations. In the end, this will allow each user to select and implement the best CPCs for their application, fighting corrosion in the most efficient way possible.

In summary, Naval aircraft will continue to operate in a severe environment, under difficult and constrained maintenance conditions, and with increasing environmental and cost burdens. To combat this, NAVAIR is working to invent, demonstrate, validate, and implement new technologies to fight corrosion, while lowering the overall cost. Many specific corrosion-related activities are being pursued with both direct benefits and some additional indirect benefits being realized. These include the elimination of duplicate efforts, establishment of a corrosion network of experts, and dissemination of lessons learned across platforms.

Air Force, Air Force Research Laboratory

Overview

The Materials and Manufacturing Directorate of the Air Force Research Laboratory (AFRL/ML) has several corrosion programs that address corrosion detection through Nondestructive Evaluation, corrosion protection through CPCs, corrosion inhibitors and control through materials and processes (M&P) testing, and corrosion-related failure analysis.

The objective of NDE is to develop and enhance corrosion detection methods that will enable older aircraft systems to continue to operate safely well beyond their original design lifetimes. Semi-automated scanning methods with both ultrasonic transducers and multi-frequency eddy current probes are enhancing the ability to scan for corrosion damage in second layers in transport fuselage structures. New digital x-ray technologies are being developed to reduce the hundreds of millions of dollars being spent for x-ray film, processing, and related hazardous waste stream treatment. In the long term, AFRL/ML will focus on new distributed sensor technologies in combination with powerful data processing, archiving, and discrimination algorithms, which greatly improve the reliability of our systems at a reduced cost. Embedded sensors combined with wireless, miniaturized communication, power scavenging, highly refined signal processing and data management technologies are needed for health monitoring of critical systems, subsystems, and components. If long-term health monitoring is required to move beyond current statistically based scheduling of weapon system maintenance to the more cost effective mode of fixing problem components only when needed. This process of state awareness for maintenance prognosis developed along the lines of a biological central nervous system is the next major hurdle for non-destructive evaluation.

The Aircraft Corrosion Protection Coatings Program is focusing on reducing the substantial maintenance costs associated with corrosion control on DoD equipment while meeting the pollution prevention requirements of Executive Order 12856. This is being accomplished through an understanding of novel, less understood aircraft surface treatment procedures such as self-assembled nanophase coatings (SNAP) and nanoscale functionally tailored surface treatments. Through the use of sophisticated tools for high durability, AFRL/ML is investigating highly durable advanced coating formulations.

The Corrosion Control and Evaluation Team maintains personnel and laboratory facilities in order to provide both technical consultation and short-term laboratory evaluation support to Air Force procurement and user personnel in the areas of corrosion, corrosion protection, and materials compatibility. As such, the team uses a combination of research and development (3600), and operations and maintenance (3400) dollars to evaluate technologies for transition ability as well as conduct situational evaluations to support specific customer needs/problems.

Major Goals, Objectives, and Metrics

Major goals of the AFRL/ML NDE Program are corrosion detection in complex, multi-layered structures and quantification of corrosion damage. Material loss and pit depth are two key corrosion parameters that are critical for NDE detection. They affect structural integrity by increasing the stress intensity factor, which in turn drives the fatigue crack to a critical flaw size resulting in failure. Transition and implementation of handheld, semi-automated, portable tools (Mobile Automated Scanner [MAUS] IV) for multi-layer inspection capability is being accomplished using Aeronautical Systems Center funding with technical management by AFRL/ML. Recent emphasis has been to reduce the maintenance inspection burden through condition-based maintenance and moving towards integrated vehicle health monitoring (IVHM) in which prognostics will play a much more significant role than the current post mortem diagnostic NDE techniques. IVHM will require on-board corrosion (and fatigue) sensors that will detect and monitor corrosion-damage growth. Signals from the sensors will have to be acquired and processed by a microprocessor that will determine the extent of corrosion damage and vehicle’s health.

The major goal of the Aircraft Corrosion Control and Coatings Programs is to substantially reduce costs associated with corrosion control through developing (1) environmentally acceptable paints/coatings, metal plating, surface preparation, and cleaning processes that do not rely on hazardous materials to prevent corrosion of aircraft and (2) advanced aircraft extended-life coating capability with a 30- to 40-year environmentally compliant foundation layer for corrosion protection and an 8-year durable camouflage topcoat. The M&P coatings development is done through a research base that investigates structure or property relationships, develops fundamental understanding of key mechanisms, and validates model concepts and materials.

The Corrosion Control and Evaluation Team provides quick technical and laboratory support to both developing and fielded Air Force systems experiencing corrosion and/or environmental degradation (rain or dust erosion) problems. The team transitions corrosion prevention and control technologies to the warfighter, and it transitions lessons learned from historical experience to system program offices.

Recent Accomplishments

The Advanced Coatings Research Group recently performed a critical examination of various surface preparation and cleaning procedures. These procedures have a dramatic impact on copper and magnesium concentration at the alloy surface. The biggest impact of this research was learning that alloy corrosion is dependant upon preparation and cleaning procedures, average current density changes almost an order of magnitude based on cleaning procedure.

The Corrosion Control and Evaluation Team supported the Large Framed Aircraft Decontamination Demonstration (LFADD) Program to validate decontamination strategy/effectiveness. They provided laboratory testing that identified critical materials compatibility issues with proposed simulated chemical agents and identified a qualification protocol for identifying simulated chemical agents that did not pose a risk to aircraft structure.

The Corrosion Control and Evaluation Team evaluated F-16 wiring harness electrical failures. They determined that failures resulted from connector housing corrosion. They also identified protective measures to eliminate future failure. The Corrosion Control and Evaluation Team also evaluated alternate lavatory “blue water” mixtures. They identified a mixture that introduced the least potential for structural corrosion in Air Force aircraft. Field implementation of the identified mixture is eliminating corrosion that results from spills in regions of the aircraft that cannot be inspected.

The Corrosion Control and Evaluation Team conducted a field correlation of a new accelerated corrosion test (GM9540) to real world corrosion at several Air Force bases. Correlation will allow accelerated test exposure time to be selected that accurately simulate real-world exposures experienced by aircraft.

The NDE Team conducted laboratory and depot-level demonstrations of pulsed eddy current systems adapted to two depot-level inspection platforms (MAUS and UltraImage). These demonstrations were conducted to show the progress toward the transition of this technology and to incorporate the depot inspectors’ critiques into the system development.

The NDE Team also delivered two digital x-ray detectors to Oklahoma City Air Logistics Center (ALC) for aircraft and engine component inspections. These systems demonstrate the cutting edge of real-time inspection technology with high resolution for crack and corrosion detection. The ALC has primarily used these systems for engine oil tank and cooler inspection (component alignment and integrity) and aircraft control surface (foreign object damage and moisture) inspection.

Defense Advanced Research Projects Agency

Overview

Development of long-term, corrosion-resistant coatings in saline environments is key to development of future, advanced Naval surface combatants and amphibious vehicles for the U.S. Marine Corps. The reliable attainment of the required properties through the manufacturing and processing frequently paces the procurement, deployment schedule, cost, and, most critically, the availability of combat systems. The potential for dramatic corrosion performance enhancements combined with enhanced blast/fragment protection, durability, wear resistance, and cost savings in the design and fabrication of future Defense systems are the drivers behind this technology development program

Major Goals, Objectives, and Milestones

Develop a derivative class of high-performance structural amorphous metal coatings for long-term corrosion resistance in saline environments.

- Synthesize amorphous alloy coatings based on corrosion-resistant alloys (exceed performance of type 316L stainless steel, Alloy 22, and titanium)
- Establish processing parameters (windows) for applying and controlling attributes of amorphous coatings
- Demonstrate certifiable properties in excess of state-of-the-art materials
- Develop processing and predictive behavior models
- Fabricate prototype components and package.

Major Recent Accomplishments

Effort initiated in August 2003. Results are not yet available.

Strategic Environmental Research and Development Program and Environmental Security Technology Certification Program

In addition to the activities described above, specific environmental-related corrosion prevention and mitigation activities are being coordinated under of the auspices of the Strategic Environmental Research and Development Program (SERDP) and the Environmental Security Technology Certification Program (ESTCP). Specific projects that are either underway or planned are listed in Table III-5.

Table III-5. SERDP and ESTCP Projects

Project category	Project title
SERDP Projects	
Coatings	Novel conductive polymers as environmentally compliant coatings for corrosion protection
	Environmentally compliant sprayable low observable coatings that facilitate rapid removal and repair
	Low-temperature powder coatings
Material or process substitution	Clean dry-coating technology for chrome replacement
	Corrosion-resistant steels for structural applications in aircraft
	Chromium-free coating system for DoD applications
	Zeolite conductive polymer coating system for corrosion control to eliminate hexavalent chromium from DoD applications
	Investigation of chemically vapor deposited aluminum as a replacement coating for cadmium
	Electrolytic plasma processing for sequential cleaning and coating deposition for cadmium plating replacement
	Electroactive polymers as environmentally benign coating replacements for Cd plating on high-strength steels
Other	Critical factors for the transition from chromate to chromate-free corrosion protection
ESTCP Projects	
Coatings	Demonstration and validation of low-VOC barrier coating for industrial maintenance
	Scale-up, Dem/Val radar-absorbing material (RAM) coatings
Material or process substitution	Aluminum-manganese molten salt plating
	Cadmium replacements for DoD and NASA
	Replacement of chromium electroplating on gas turbine engine components using advanced thermal spray technologies
	Replacement of chromium electroplating on helicopter dynamic components using high velocity oxygen fuel (HVOF) thermal spray technology
	Electrospark deposition for depot- and field-level component repair, and replacement of hard chromium plating
	Demonstration and validation of corrosion-resistant steels for structural applications in aircraft using an accelerated insertion methodology
	Demonstration and validation of barrier coating/selective coating removal technology on DoD weapon systems
	Nanocrystalline Co alloy plating for replacement of hard chrome and other materials on internal surfaces
	Demonstration/validation of environmentally compliant low observable coating that facilitates rapid removal and repair
Nondestructive inspection (NDI)	Scale-up, environmentally friendly NDI for corrosion inspection through coatings

Communications and Outreach

Long-term Strategy Components
• Policy and Requirements
• Impact, Metrics, and Sustainment
• Science and Technology
• Communications and Outreach
• Facilities
• Training and Doctrine
• Specifications/Standards and Product Qualification

One of DoD's major corrosion prevention and mitigation goals pertains to the collection and dissemination of corrosion data and information. Therefore the following are among the critical objectives of the Communication and Outreach WIPT:

- Initiate the DoD Corrosion Exchange website.
- Identify other government agencies that can assist with DoD corrosion issues.
- Enhance the DoD information and data exchange website.
- Identify "corrosion ambassadors" to participate in pertinent forums.

Corrosion mitigation is an inherent component of all sustainment programs, and transmission of technical issues and information back to program offices may not be optimal. The DoD Corrosion Executive will ask the Assistant Secretaries of each of the Services and the Joint Logistic Commanders to address and resolve these barriers to communication.

While specific requirements or methods will not be dictated, there may be a need to illustrate the problem and suggest approaches and known solutions. The Communication and Outreach WIPT will work with the various Service organizations and industry, standards organizations, and professional societies to improve the data collection and dissemination policies and procedures.

The Communications and Outreach WIPT has achieved noteworthy progress toward meeting many of its objectives. The WIPT has

- developed the DoD Corrosion Exchange website, www.DoDCorrosionExchange.org;
- established a relationship with the NACE International—The Corrosion Society; and
- forged a working relationship with the Advanced Materials and Processes Technology Information Analysis Center, and published a special issue of the *AMPTIAC Quarterly*, outlining DoD corrosion policy, program, and requirements.

DoD Corrosion Exchange

The designated Communications and Outreach WIPT is charged with developing and implementing a broad and accessible web-based knowledge foundation. The initial and most important task of the WIPT was to establish the DoD Corrosion Exchange website.

The website is actually an enhancement to an existing DoD logistics website sponsored by DUSD for Logistics and Materiel Readiness (L&MR). The site enables the accomplishment of numerous objectives, including supporting and improving communication, collaboration, and coordination within the corrosion community; increasing the effectiveness of corrosion prevention and control research and operations; identification and dissemination of lessons learned; developing, maintaining, and expanding the web-based information aggregation and sharing capabilities of the website; and maintaining a content-rich, collaborative-enabled online environment for all members.

The websites for the Services' centers of excellence also will be listed, including the following:

- Army
  - ERDC: www.cecer.army.mil/td/tips/browse/products.cfm
  - COE: www.sam.usace.army.mil/en/cp/COE
  - CCTP: www.cecer.army.mil/pl/project/index.cfm?RESETSITE=cctp
- Navy
  - E-net: navfacilitator.navfac.navy.mil/cheng/enet/lessons/lessons.htm
  - CP: pwtc.nfesc.navy.mil/CathProt/cathodicprotection.htm
  - Coatings: coatings.nfesc.navy.mil/
  - Specialized Expertise: pwtc.nfesc.navy.mil/
  - Naval Sea Systems Command's (NAVSEA's) National Surface Treatment Center: NSTCenter.com
- Air Force Engineer Support Agency (AFCESA): www.afcesa.af.mil/Publications/default.htm.

In order to facilitate communication within the IPT, a special interest group has been formed on the website. IPT presentations, minutes, etc. will be posted and the information-sharing and knowledge management aspects of the website will continue to be tested and refined.

The website (Figure III-3) was activated in August 2003 and has undergone targeted updates to incorporate user recommendations.

Figure III-3. Website Welcome Screen

NACE International—The Corrosion Society

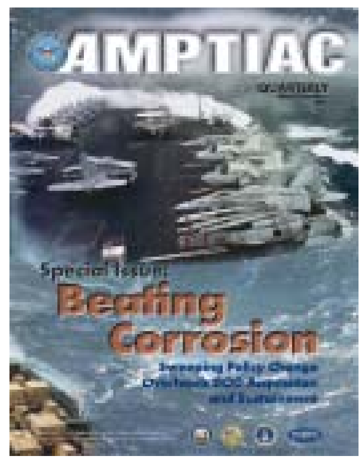
NACE is a professional technical society that offers technical training and certification programs, sponsors conferences, and produces industry standards and reports, publications, and software. With more than 15,000 members, NACE is dedicated to advancing the knowledge of corrosion engineering and science. NACE is considered an important resource in addressing corrosion.

AMPTIAC

The Defense Technical Information Center (DTIC) sponsors the Advanced Materials and Processes Technology Information Analysis Center, which was established under competitive contract in 1996 and receives management and technical oversight from OSD(DDR&E).

AMPTIAC is operated for DoD by Alion Science and Technology and provides a wide range of corrosion-related functions, including inquiry services, newsletter, data gathering and analysis, and product development (state-of-the-art reviews, technology assessments, and databases).

AMPTIAC published a special DoD corrosion issue,[4] which promoted the mission of the Office of Corrosion Policy and Oversight and



- introduced the new DoD corrosion policy;
- introduced the new Corrosion Policy and Oversight Office;
- highlighted achievements and ongoing corrosion management activities of the Services;
- raised awareness of corrosion resources (new and established); and
- advocated the importance of corrosion management to policy makers.

This 84-page issue was directly targeted toward stakeholders in the DoD corrosion prevention and control community. Copies were provided to all attendees at the 2003 Tri-Service Corrosion Conference held November 17–21, and copies will be given to attendees at this year's Program Executive Officer/Systems Command conference at Fort Belvoir on December 3–5, 2003. In addition, copies will be directly mailed to a large number of DoD program managers and acquisition personnel, as well as to over 10,000 *AMPTIAC Quarterly* subscribers.

AMPTIAC also compiled a list of corrosion-relation citations (provided in Appendix E) that identifies more than 142,000 reports from AMPTIAC, the Defense Research, Development, Test, and Evaluation (RDT&E) Online System (DROLS), NASA, the Department of Energy (DOE), the Department of Transportation (DOT), and the Department of Commerce (DOC). These citations reference existing corrosion-related technical reports and information that can directly support current initiatives.

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[4] *AMPTIAC Quarterly*, Volume 7, Number 4, Winter 2003.

JCAA

The Joint Council on Aging Aircraft is a key component of the Department's corrosion prevention and mitigation program. The JCAA, an action board under the Joint Aeronautical Commanders Group (JACG), established the Corrosion Steering Group (CSG) in 2002 to address corrosion as a pervasive issue across all participating Services and Agencies. As such, its membership includes representation from seven different organizations: the Air Force, Navy, Army, Defense Logistics Agency, Coast Guard, NASA, and the Federal Aviation Administration. The CSG consists of technical corrosion experts that assist in identifying technology deficiencies, review current and planned programs, and coordinate technical interchanges between the participating government agencies and the aerospace community. The lead points of contact for the CSG also participate in the CPCIPT.

The major goals for the CSG are to coordinate and collaborate on technologies, which span basic research to advanced development technologies, transition, and field implementation. The four initial focus areas for the CSG are Prevention, Analysis, Repair and Data Management; and specific CSG objectives are concentrated on technology road mapping, information dissemination, and training in these areas. Metrics include technology areas road-mapped, specific collaborative technology initiatives, and joint technology implementations.

The CSG has been investigating several specific technology initiatives:

- A clear water rinse facility based on an Army effort aimed at demonstrating a drive-through capability for rotary-wing aircraft. This effort is focused on defining the system requirements and processing parameters for operations. Each Military Service or Defense Agency identified potential targeted platforms, investigated their requirements for this system and identified existing capabilities. Various common rotary wing platforms (including the H-60, H-53, and V-22, as well as the H-46, H-64, and H-47 service-unique platforms) were identified and a cross-agency disposition for this initiative has been defined. The Air Force, Navy, and Coast Guard all have some rinse facilities currently in operation at various locations (example P-3 drive-through facility at Naval Air Station Jacksonville) and the Army is pursuing installation at several Army bases. As a spin-off from this effort, the Navy has been incorporated into the Air Force's geographical corrosion assessment effort with 10 Navy sites targeted and outfitted with the test platforms for analysis and an eleventh site is being pursued. The Coast Guard also has sites of interest in this effort.
- Corrosion control kits based on a Navy effort involving a self-contained kit, which incorporates technologies for spot corrosion repair and re-finish/touch-up. Technologies for this kit include a radial bristle disc for light surface corrosion removal and another disc designed to treat heavier corrosion, surface pitting, and sealant removal. Along with this corrosion removal tool, the kit includes touch up pretreatments and coatings for aircraft and support equipment. The evaluation data generated by the Navy was shared with the other agencies for validation and implementation at their facilities. In addition, specific agency finishing system materials have been investigated for incorporation into the touchup coating kits. Unique Service or Agency requirements are being addressed to fully transition the technologies throughout the CSG. The Navy, Air Force, and Coast Guard have deployed these technologies to varying degrees, and the remaining issues for Army deployment are being addressed.

- An assessment of the state-of-the-art of corrosion preventive compound technology including: products, material designations, testing criteria, and usage of these products. The primary product is a technology roadmap, which has been developed and outlines each agency's pursuit of these products. Joint technology demonstrations have been identified and are being pursued. One example of this is the Air Force–sponsored CPC demonstration on a Coast Guard C-130 aircraft. The Navy halted pursuit of its own demonstration in favor of following this effort.

In summary, many corrosion-related activities are being pursued by the CSG with direct cross-agency benefits and some additional indirect benefits from this effort have been realized. These include the elimination of duplicate efforts, establishment of team infrastructure, and establishment of data warehousing for information consolidation, as in the case of CPCs, and dissemination of lessons learned across Defense Agencies. In the future the focus will continue to target the mapping of corrosion areas (such as prognostics and diagnostics, aircraft corrosion mapping, and finishing system technology) and will establish new joint efforts in areas of common interest.

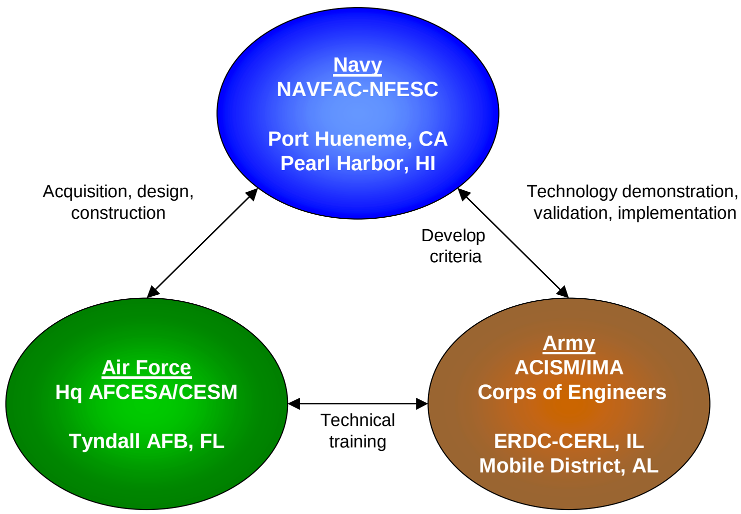
Facilities

The Tri-Services Facilities Corrosion Control Network continues to enhance its ability to address the corrosion-related areas depicted in Figure III-4. Interservice efforts in acquisition, design, and construction; criteria development; technology demonstration, validation, and implementation; and technical training will improve DoD's ability to prevent and mitigate facilities corrosion.

Long-term Strategy Components

- Policy and Requirements
- Impact, Metrics, and Sustainment
- Science and Technology
- Communications and Outreach
- Facilities
- Training and Doctrine
- Specifications/Standards and Product Qualification

Figure III-4. Tri-Services Facilities Corrosion Control Network



The Tri-Services Facilities Corrosion Control Network has identified additional potential corrosion projects in support of the long-term mitigation strategy, including corrosion surveys; noncorroding materials selection; upgrade of cathodic protection systems; high-performance coatings; high-performance, non-hazardous corrosion inhibitors; centers of expertise; and training. The Services currently have programs and guidance in place, and continue to try to identify the funding and resources (e.g., trained manpower) to implement the initiatives.

Each of the projects is important, but the centers of expertise are particularly critical because the centers play a critical role in implementing the Facilities Corrosion Control Program (specifically in the development and updating of corrosion-related criteria). Therefore, the centers will develop and update a number of documents including the following

- Information manuals
    - NAVFAC Maintenance and Operations Manual (MO)-307 *Corrosion Control*, updated to UFC
    - Army/COE unified facilities criteria (UFC) for corrosion control program created
    - Air Force Instruction 32-1054, *Corrosion Control*.
    - Division 02 (Site Construction) manuals (e.g., 02456A USACE 02/98 Steel H-Piles)

    - Division 03 (Concrete) manuals (e.g., 03311 NAVFAC 09/99 Marine Concrete)
    - Division 09 (Finishes) manuals (e.g., 09900 NAVFAC 02/02 Paintings and Coatings)
- Design criteria
    - *Coatings Handbook* revised for publication as UFC this year (formerly MIL HDBK 1110/1)
    - Cathodic protection (CP) design manuals MIL HDBK 1004/10 and Technical Manual 5-811-7 (Update to UFC 3-570-07 ongoing)
    - 6 CP and 30+ coating guide specifications
    - Army and Air Force Engineer Technical Letters, and Navy Infrastructure Technology Group documents
- O&M manuals
    - CP O&M manual UFC 3-570-06 (released January 2003)
    - CP field handbook MIL HDBK 1136/1(AF HDBK 32-1290)
    - Updating UFC 3-240-13, *Operations and Maintenance: Industrial Water Treatment*, ECD 2004.

The Tri-Service Network also identified a number of focus areas during its field user group meeting, held in conjunction with the NACE National 2003 conference in March 2003. The following were among the key focus areas:

- Additional training is required. (Funding is required or should be earmarked for training.)
- Corrosion control must be considered early in the planning and design, instead of being a post-construction maintenance item.
- Specifications that allow contractors to freely substitute materials of construction need to be revised. (Substitutions can lead to corrosion problems.)
- More money needs to be earmarked specifically for corrosion control work in the field.

Training and Doctrine

Objectives for the training and doctrine long-term strategy include the following:

Long-term Strategy Components
- Policy and Requirements
- Impact, Metrics, and Sustainment
- Science and Technology
- Communications and Outreach
- Facilities
- Training and Doctrine
- Specifications/Standards and Product Qualification

- Identify potential training shortfalls for the workforce at all levels.
- Identifying potential shortfalls in continuous training/certification.
- Establish training requirements (e.g., course development, training materials, trainers, and training sites).
- Develop a "Corrosion 101" course.

The Defense Acquisition University recently revised its lesson plans to include corrosion-related training for system engineers, contract specialists, and program managers. The training, in addition to providing basic knowledge regarding corrosion and its effects, focuses on

- "awareness" and policy for program managers,
- preventive technology for engineers,
- basic knowledge and remediation for maintainers, and
- prevention for users.

An additional assessment of training delivery systems (Table III-6) supports the ongoing web-based efforts. Future training likely will address a need for a high-level mandate to invoke a training requirement, the requirement for continuing resources, periodic auditing, and extensive record keeping.

Table III-6. Training Delivery—Pros and Cons

Training type	Pros	Cons
On-the-job	Hands-on/practical Low cost	Limited scope Inconsistent from shop-to-shop
Classroom	Uniform Full scope May include limited hands-on Flexible content Proficiency testing	Rigid schedule Costly Difficult to maintain due to personnel rotation
Web-based	Uniform Full scope Flexible content Flexible schedule Proficiency testing Moderate cost	No hands-on/practical No computer resources

Specification/Standards and Product Qualification

The Need for Specifications, Standards, and Product Qualification

Long-term Strategy Components

- Policy and Requirements
- Impact, Metrics, and Sustainment
- Science and Technology
- Communications and Outreach
- Facilities
- Training and Doctrine
- Specifications/Standards and Product Qualification

The pervasive nature of military equipment and facility corrosion in the Department dictates the requirement to control corrosion at product sources and operating sites. In many cases, the most affordable approach is to select materials, designs, and production processes that prevent systems, equipment, facilities, or other physical infrastructure units from corroding after they are delivered to the DoD. When prevention is not feasible or products fail to resist corrosion, then various forms of corrosion mitigation must be employed.

Corrosion mitigation processes include detection and measurement of the extent of corrosion, physical removal of corrosion from affected materials, treatment to forestall or retard further corrosion, and removal and replacement of corroded systems or structures. Effective corrosion prevention and mitigation depends on development and implementation of processes that can achieve the required corrosion control, and determination that the results of these processes met established quality levels.

To ensure products and processes consistently display attributes and performance characteristics that effectively prevent or mitigate corrosion, the broad community of manufacturers and users have developed specifications, standards, and qualification processes. The development, selection, application, and improvement of these specifications, standards, and qualification processes represent several years of substantial work. Recently, the Department has overseen a gradual transformation from almost entirely physical specifications and standards to a balance of physical and performance-based requirements. At the same time, the near total DoD responsibility for the development and maintenance of many of these specifications and standards has largely migrated to the civilian sector. These recent developments in content and responsibility have received general approval, but also have raised important issues regarding standardization, consistent application, responsibility for maintenance, and interagency communication. As a result of these and other issues, and because of the broad impact of specifications, standards, and qualification processes on effectively preventing and mitigating corrosion and its effects, the DoD Office of Corrosion Policy and Oversight organized the Specification/Standards and Product Qualification Focus Group as part of the Corrosion Forum, and subsequently designated it as a chartered working integrated product team.

Policy, Objectives, and Strategy

The Specifications, Standards, and Qualification Process (SSQP) Focus Group developed an integrated approach to resolving issues and creating a viable SSQP plan based on the following policies, objectives, and strategy.

Policy

- Increase support for standards and product qualification by establishing a Qualified Products List process.
- DoD will use commercial specifications and standards for both infrastructure and military equipment when deemed appropriate. When current commercial specifications and standards do not meet requirements, DoD will seek to modify current standards or write new ones. When commercial approaches are not feasible, only then will military specifications and standards be established.

SSQP Focus Group Objectives

- Create a framework within which the DoD can effectively manage a standardized, consistent, Department-wide way of selecting, applying, and updating appropriate specifications, standards, and qualification processes, while eliminating those that are superfluous or outdated.
- Integrate the best industry, association, and DoD specifications, standards, and qualification processes with methods for selecting, applying, and maintaining these documents and processes.
- Ensure effective, accessible, web-based communication methods and information are available to the SSQP community.
- Address and resolve SSQP issues within the DoD and with the rest of the corrosion control community.
- Incorporate the results of achieving the four previous objectives in a long-range SSQP roadmap that describes how the Department will implement effective SSQP management and control.

Strategy

The SSQP Focus Group developed the following strategy for implementing the above policies and long-term objectives:

- Develop methods to assess, apply, revise, improve, or develop specifications and standards.
  - Identify, update, or consolidate databases for application and historical reference by DoD and contractors.
  - Collect, assess, and prioritize specifications to establish a specifications and standards roadmap by categories.

- Establish, refine, and develop qualification process steps to effectively introduce products into DoD systems.
    - Develop a decision tree.
    - Improve interservice standardization, communication, and coordination by requiring accreditation and implementing a website.

Planned Actions

Historical Review

The SSQP Focus Group surveyed and assessed the recent transformation of policies, processes, and responsibilities associated with specifications, standards, and qualification and found significant overall improvement as well as notable individual success. The group also discovered that, while individual Services and industry organizations were becoming increasingly effective, there was a need for

- standardization of processes within the combined DoD military and civilian community;
- inclusion of more government and commercial organizations in the planning and execution of standard SSQP approaches;
- common, accessible databases of specifications and standards; and
- interservice and interagency communication of best practices, process results, and other information vital to continued improvement in quality and standardization of the SSQP.

These conclusions led to the generation of short- and long-term action items and the detailed planning of a SSQP roadmap for subsequent execution.

Short-Term Actions

The SSQP Focus Group undertook short-term actions to lay the foundation for implementing the SSQP strategy. These actions included

- collecting specifications and standards and categorizing by technology;
- revising existing policy to accommodate military specification development for military-unique technologies and to accelerate technology transfer;
- working with DoD specification and standards boards to implement corrosion specifications, standards, and requirements;
- identifying accreditation requirements associated with corrosion technologies;
- modifying or updating high-priority DoD specifications; and
- introducing a materials and processes decision tree.

Long-Term Actions

The SSQP Focus Group established long-term actions designed to build the structure for implementing the SSQP strategy. These actions include

- identifying pertinent databases;
- defining the methods for using available databases;
- submitting pertinent information regarding the historical transformation of SSQP policies, processes, and responsibilities;
- generating an SSQP roadmap that details the steps to be taken to implement an improved, standardized process for selecting, applying, and updating specification and standards processes, and a common qualification process for approving and acquiring materials, systems, facilities, and other products;
- developing a standard, common qualification process that includes a roadmap for maintaining an updated qualified parts list; and
- ensuring that SSQP-related information is readily accessible to the entire corrosion control community.

Results

Databases

The SSQP Focus Group identified a number of databases associated with specifications and standards. The specific database with the potential to be most useful is the Acquisition Streamlining and Standardization Information System (ASSIST) Database, <assist.daps.dla.mil/online/start>. Other databases include the DoD Corrosion Exchange database, the American Society of Naval Engineers (ASNE) database, the AMPTIAC database, and the NACE database.

Specifications and Standards Roadmap

The following are among the actions undertaken or completed with respect to developing a specifications and standards roadmap:

- The taxonomy of specification and standards categories was created to address the three broad areas of corrosion prevention, detection, and maintenance. This is important to the process of classification and subsequent detailed review of specifications and standards to determine status and requirements.
- Lists of specifications and standards used by DoD, government, and commercial organizations for their specific applications are being received and consolidated to identify both availability and commonality among Services and Agencies.

- Tools to be featured in the roadmap were identified. These tools will be available for program managers and other science and technology or acquisition managers to use in the selection and application of the best specifications and standards.
- Elements of the roadmap was identified. These elements include establishing a baseline of current tools and methods; identifying needed tools; describing effective application methods, defining methods for updating specifications and standards; and ensuring requirements are met by contractors.

Qualification Process

The following are among the actions undertaken or completed regarding development of a standard, common qualification process:

- A "straw-man" qualification process decision tree was created and will be fleshed out and modified during SSQP WIPT efforts.
- Steps in the qualification process were established and defined. These steps include vendor "marketing" guidance, prescreening processes, testing methods, certification requirements, implementation approaches, and product review procedures.

Interservice Communication

The following were among the actions undertaken or completed to enhance standardization, communication, and coordination:

- Members of the SSQP WIPT documented a number of corrosion specifications, standards, and qualification process topics to be featured in an upcoming AMPTIAC publication.[5] These and other articles will be featured on the DoD Corrosion Exchange website described earlier under "Communications and Outreach."
- The DoD Corrosion Exchange website will be the focal point for communicating qualification requirements associated with interservice standardization, communication, and accreditation coordination.

[5] Ibid., *AMPTIAC Quarterly*, Winter 2003.

Section IV
Major Objectives, Milestones, and Status

Figure IV-1 is done in Microsoft Project format.

Figure IV-1. CPC Project Schedule (Version 1)

DoD Corrosion Policy and Oversight Strategy Action Summary (Version 1)

Task Name	New Equip	Existing Equip	New Facilities	Existing Facilities
DoD Corrosion Prevention and Mitigation				
Strategic Direction				
Vision	X	X	X	X
Mission and Policy	X	X	X	X
Management Strategy				
Organization Phase	X	X	X	X
Establish Office of Corrosion Policy and Oversight	X	X	X	X
Planning Phase	X	X	X	X
Develop and publish Long-term Corrosion Strategic Plan (Spiral 1)	X	X	X	X
Congressional Reporting Requirements (per 10 USC 2228)				
Designation of responsible official or organization	X	X	X	X
Interim Report	X	X	X	X
Long-term Strategy Report	X	X	X	X
Policy and Requirements Long-Term Strategy Component				
Policy				
Develop overarching DoD corrosion policy and publish DoD corrosion regulation or instruction	X	X	X	X
Include R&D in DoD 5000 series and in overarching policy	X			
Retain corrosion prevention and mitigation planning, management and control in DoD 5000 Guidebook	X			
Assess language in the DFAR that stresses corrosion planning and management as part of the procurement process	X			
Retain sustainment language in 5000.1 with stronger acquisition direction desirable	X			
Assess corrosion control plan in 5000.2	X			
Establish a DoD Corrosion Policy and Oversight IPT	X	X	X	X
Develop and publish CPC Planning Guidebook	X	X	X	X
Requirements				
Define, collect and assess programmatic and technology requirements (shortfalls, priorities, impact, etc.)	X	X	X	X
Develop and manage corrosion roadmap	X	X	X	X
Consider future systems and forward operating environment effects on corrosion requirements	X	X	X	X
Create joint test protocols across the Services	X	X	X	X
Evaluate changes in corrosion requirements dictated by new DoD philosophies and strategies	X	X	X	X
Determine and alleviate critical shortages in manpower, training, and funding		X		X
Review current corrosion programs and funding levels and recommend future programs and funding to mitigate impacts	X	X	X	X
Create prioritization matrix for programs with emphasis on transition for implementation plans	X	X	X	X
Impact, Metrics, and Sustainment Long-Term Strategy Component				
Impact				
Assess previous cost of corrosion studies		X		X
Develop methodology to identify DoD cost of corrosion (continuous)		X		X
Proliferate information on the impact on safety, readiness, maintainability, weapon system life, reliability, and durability	X	X	X	X
Provide corrosion related funding (continuous)	X	X	X	X
Metrics				
Develop initial metrics set	X	X	X	X
Develop, continuous improve and track performance metrics of new materials and processes	X	X	X	X
Sustainment				
Support technical management of specs/standards	X	X	X	X
Establish methods to track R&D product effects on impact	X	X	X	X
Identify "quick hit" projects for funding	X	X		
Continue equipment corrosion-related R&D efforts	X	X		
Science and Technology Long-Term Strategy Component				
Develop Joint Service road map for coordinated S&T	X	X	X	X
Establish knowledge base by platform, infrastructure, and material type	X	X	X	X
Establish knowledge base (work with Outreach and Communication Focus Areas)	X	X	X	X
Develop websites, manuals, instructions for corrosion protection technologies	X	X	X	X
Establish mechanisms for problems to be identified and conveyed to R&D		X		X
Continually review technology roadmap following product development from inception to implementation	X	X	X	X
Identify common technologies and programs	X	X	X	X
Identify Service-specific technologies and programs	X	X	X	X
Review and assess corrosion-related R&D programs and projects, and compare to requirements and resources	X	X	X	X
Facilities Long-Term Strategy Component				
Identify "quick hit" projects for funding			X	X
Continue facility corrosion-related R&D efforts			X	X
Communications and Outreach Long-Term Strategy Component				
Initiate OSD Corrosion Control website	X	X	X	X
Identify other government agencies that can assist with DoD corrosion problems	X	X	X	X
Coordinate program to eliminate redundant efforts among the Services and to leverage available funding	X	X	X	X
Identify "corrosion ambassadors" to participate in conferences	X	X	X	X
Expand/enhance DoD information/data exchange website	X	X	X	X
Produce and publish special corrosion edition of AMPTIAC Quarterly	X	X	X	X
AMPTIAC research and publication of a Summary of Corrosion Control Citations	X	X	X	X
Training and Doctrine Long-Term Strategy Component				
CPC rapid deployment video stream presentation	X	X	X	X
Make corrosion training available to workforce at all levels	X	X	X	X
Identify potential shortfalls in workforce requiring continuous training/certification		X		X
Identify and review training requirements (e.g., course development, training materials, trainers, and training sites)	X	X	X	X
Develop "Corrosion 101" course	X	X	X	X
Specifications/Standards and Product Qualification Long-Term Strategy Component				
Develop methods to assess/revise existing specs/standards and develop new documentation for materials and processes	X	X	X	X
Develop history matrix to compare specifications and standards	X	X	X	X
Develop decision tree	X	X	X	X
Require accreditation of QA/QC processes and consistent implementation of QPL/APL	X	X	X	X

Appendixes

Appendix A
Policy Memorandum

THE UNDER SECRETARY OF DEFENSE

3010 DEFENSE PENTAGON
WASHINGTON, DC 20301-3010

ACQUISITION,
TECHNOLOGY
AND LOGISTICS

NOV 12 2003

MEMORANDUM FOR SECRETARIES OF THE MILITARY DEPARTMENTS

SUBJECT: Corrosion Prevention and Control

The Department of Defense (DoD) acquires, operates, and maintains a vast array of physical assets, ranging from vehicles, aircraft, ships, and other materiel to wharves, buildings, and other stationary structures that are subject to corrosion. Consequently, corrosion control contributes significantly to the total cost of system ownership. To control these costs, I believe we need to revitalize our approach to tracking, costing, and preventing or controlling corrosion of systems and structures. Specifically, we need to concentrate on implementing best practices and best value decisions for corrosion prevention and control in systems and infrastructure acquisition, sustainment, and utilization.

Basic systems design, materials and processes selection, and intrinsic corrosion-prevention strategies establish the corrosion susceptibility of Defense materiel. The early stages of acquisition provide our best opportunity to make effective trade-offs among the many competing design criteria that will provide desired Defense capability. I believe that corrosion needs to be objectively evaluated as part of program design and development activities and the inevitable trade-offs made through an open and transparent assessment of alternatives. Therefore, I want this requirement to be specifically addressed during the earliest phases of the acquisition process and by decision authorities at every level. I will personally consider this issue for programs subject to Defense Acquisition Board (DAB) Review.

I have directed that a review and evaluation of corrosion planning be a standard topic for the Integrating Integrated Product Team reviews and that the Corrosion Prevention and Control Planning be reviewed by the Overarching Integrated Product Team with issues raised by exception to the DAB. To assist all of us in designing effective strategies, corrosion prevention and control planning guidance will be included in the "Designing and Assessing Supportability in DoD Weapons Systems" guidebook. We are also drafting a "Corrosion Prevention and Control Planning Guidebook," which will provide assistance in general corrosion-control planning and the implementation of sound materials selection and treatments during the design, development, and sustainment of DoD weapons systems and infrastructure.

Thank you for your support as we develop a long-term DoD corrosion prevention and control strategy. My focal point for this effort is Mr. Daniel Dunmire, Director, Corrosion Policy and Oversight, at 703-681-3464, e-mail daniel.dunmire@osd.mil.

Michael W. Wynne
Acting

Appendix B
Interim Report to Congress on Corrosion Matters in the Department of Defense

Section 1067 of the Bob Stump National Defense Authorization Act for Fiscal Year 2003, Pub. L. No. 107-3 14, enacted 10 U.S.C. 2228. Section 2228 requires the Secretary of Defense to designate an official or organization to he [*sic*] responsible for the prevention and mitigation of corrosion of military equipment and infrastructure. Section 2228 also requires the development of a long-term strategy for corrosion prevention and mitigation. Subsection 1067(c) requires the Secretary of Defense to submit an interim report when the President submits the budget for fiscal year 2004.

<u>Official and Organization</u>

The Principal Deputy Under Secretary of Defense for Acquisition, Technology and Logistics (PDUSD(AT&L)) has been designated as the responsible corrosion official and he has designated Mr. Daniel J. Dunmire, as the Director for Corrosion Policy and Oversight, who will be a direct report to the PDUSD(AT&L) in facilitating the Department's corrosion prevention and mitigation efforts. He will be assisted by an Air Force colonel, a research analyst, and administrative support and will be able to assign tasks within the AT&L organization.

Periodic reviews of the entire research, acquisition, and logistics programs will continue as before through conferences and symposia. There are corrosion programs throughout the Department. The aforementioned director will facilitate and coordinate the results of corrosion prevention and mitigation activities. There are established processes for coordination of the Military Departments' science and technology programs for corrosion prevention and mitigation and these processes shall continue. There are four policy and program areas within AT&L already established—science and technology, installations and environment, logistics and materiel readiness, and defense systems—that will continue to be responsible in their respective areas for prevention and mitigation of corrosion and shall support the director's efforts. Coordination and communication links are being further established with the Military Departments regarding their materiel and infrastructure programs for corrosion prevention and mitigation.

<u>Outline of a Long-Term Strategy and Milestones</u>

The long-term strategy for corrosion prevention and mitigation includes:

(1) Accelerate Modernization

The most valuable thing that the DoD could do to decrease the cost of corrosion, corrosion prevention, and corrosion mitigation is to replace aging materiel assets more rapidly. This will allow the most rapid introduction of designed-in corrosion mitigation controlled equipment.

Milestone: This is an ongoing and continuous effort that is part of the overall effort to transform the military. The intent is to purchase new kinds of systems resistant to corrosion and not to acquire newer versions of older systems. The Military Departments are being tasked to provide a roll-up of equipment being replaced or refurbished. Gathered information will be included in the December report.

(2) Close Marginal Facilities

The Department is spending a great deal of money on corrosion control and maintenance of infrastructure that is no longer necessary. Corrosion mitigation costs are wasted when spent on unneeded or marginal facilities. An example of this is a tank farm or fuel distribution system on a marginally needed base. Periodic painting of unnecessary stationary structures for corrosion control is an unneeded and indefinitely recurring expense.

Milestone: Execution of the latest Base Realignment and Closure Act will assist in reducing infrastructure expenditures and allow for funding of infrastructure mitigation and prevention at other bases. If enacted, closing unneeded facilities would reduce infrastructure expenditures and allow for funding of infrastructure mitigation and prevention at other bases.

<u>Establishing a Corrosion Information Exchange Network</u>

The revised acquisition policy directive specifically addresses corrosion prevention and mitigation in developing the program's life-cycle cost. "Program Managers shall develop and implement performance-based logistics strategies that optimize total system availability while minimizing cost and logistics footprint. Trade-off decisions involving cost, useful service, and effectiveness shall consider corrosion prevention and mitigation" Adding corrosion effects considerations to the acquisition policy helps ensure financial decisions property consider corrosion in life cycle cost calculations and in the total cost of ownership.

This policy highlights the need for continuing participation in corrosion prevention and mitigation conferences, councils, and symposia, and establishing a corrosion prevention and mitigation sharing network both inside the Department and with the professional private sector corrosion-focused organizations, i.e. NACE International: The Corrosion Society (formerly the National Association of Corrosion Engineers).

The Defense Acquisition University has developed a "Web-based best practices sharing community network." Its use will be expanded to aid in information dissemination and exchange of corrosion prevention and mitigation ideas, practices, and processes. An example of information to be shared is the Navy's aviation corrosion prevention and control program. Naval Aviation has developed and implemented disciplined corrosion control strategies and plans at all levels of command and developed templates that identify and share corrosion problems, which contribute to developing a straightforward plan to meet the challenge.

Milestone: DoD corrosion initiatives are already well established. Expanding the use of web-based communications, conferences, councils, and symposia will aid in information sharing regarding corrosion prevention and mitigation for both equipment and infrastructure. The gleaned information will be used to help refine, modify, or reemphasize corrosion prevention and mitigation. A review of these activities will be included in the December report.

Increased Support for Standards and Product Qualification

The Department relies on commercial and consensus standards for corrosion control processes and products. Even though there are ongoing Department research and development corrosion prevention and mitigation efforts, it is very important that DoD needs are covered, when and where possible, by commercial specifications and standards for both infrastructure and materiel. As new products become commercially available it is intended this information will be part of the Department's web-based communications.

The long-term strategy for corrosion prevention and mitigation for both infrastructure and materiel includes:

- Developing and testing materials, processes, and treatments that can reduce the down time, manpower, and cost associated with corrosion.
- Supporting commercial definitions for corrosion prevention and mitigation. Subsection 2228(d)(l) provides that "the term 'corrosion~ means the deterioration of a material or its properties due to a reaction of that material with its chemical environment." This is in alignment with commercial organizations' definition of corrosion.
- Continuing participation in forums, data exchanges, and cooperative projects in the Department and private sector for efficiently developing and disseminating information on corrosion.
- Developing a new or augmented strategy through a survey of current practices in each of the Services, including metrics now in use; a review of the data exchange and coordination efforts; an investigation of criteria for testing of treatments and materials; an assessment of the utility of current databases and information analysis centers; and an estimation of the manpower and funding that would be required by any recommended augmentation of the corrosion program.

Milestone: This work is ongoing. The Military Departments are being tasked to provide a roll-up of their corrosion efforts and the status will be included in the December report.

Appendix C
Section 1067 Prevention and Mitigation of Corrosion of Military Equipment and Infrastructure[1]

(a) IN GENERAL.—

(1) Chapter 131 of title 10, United States Code, is amended by adding at the end the following new section:

§ 2228. Military equipment and infrastructure: prevention and mitigation of corrosion

(a) DESIGNATION OF RESPONSIBLE OFFICIAL OR ORGANIZATION—The Secretary of Defense shall designate an officer or employee of the Department of Defense, or a standing board or committee of the Department of Defense, as the senior official or organization responsible in the Department to the Secretary of Defense (after the Under Secretary of Defense for Acquisition, Technology, and Logistics) for the prevention and mitigation of corrosion of the military equipment and infrastructure of the Department.

(b) DUTIES—

(1) The official or organization designated under subsection (a) shall oversee and coordinate efforts throughout the Department of Defense to prevent and mitigate corrosion of the military equipment and infrastructure of the Department. The duties under this paragraph shall include the duties specified in paragraphs (2) through (5).

(2) The designated official or organization shall develop and recommend any policy guidance on the prevention and mitigation of corrosion to be issued by the Secretary of Defense.

(3) The designated official or organization shall review the programs and funding levels proposed by the Secretary of each military department during the annual internal Department of Defense budget review process as those programs and funding proposals relate to programs and funding for the prevention and mitigation of corrosion and shall submit to the Secretary of Defense recommendations regarding those programs and proposed funding levels.

(4) The designated official or organization shall provide oversight and coordination of the efforts within the Department of Defense to prevent or mitigate corrosion during—

(A) the design, acquisition, and maintenance of military equipment; and

[1] Section 1067 of the Bob Stump National Defense Authorization Act for Fiscal Year 2003, Public Law 107-314, enacted 10 U.S.C. 2228.

(B) the design, construction, and maintenance of infrastructure.

(5) The designated official or organization shall monitor acquisition practices within the Department of Defense—

(A) to ensure that the use of corrosion prevention technologies and the application of corrosion prevention treatments are fully considered during research and development in the acquisition process; and

(B) to ensure that, to the extent determined appropriate for each acquisition program, such technologies and treatments are incorporated into that program, particularly during the engineering and design phases of the acquisition process.

(c) LONG-TERM STRATEGY—

(1) The Secretary of Defense shall develop and implement a long-term strategy to reduce corrosion and the effects of corrosion on the military equipment and infrastructure of the Department of Defense.

(2) The strategy under paragraph (1) shall include the following:

(A) Expansion of the emphasis on corrosion prevention and mitigation within the Department of Defense to include coverage of infrastructure.

(B) Application uniformly throughout the Department of Defense of requirements and criteria for the testing and certification of new corrosion-prevention technologies for equipment and infrastructure with similar characteristics, similar missions, or similar operating environments.

(C) Implementation of programs, including supporting databases, to ensure that a focused and coordinated approach is taken throughout the Department of Defense to collect, review, validate, and distribute information on proven methods and products that are relevant to the prevention of corrosion of military equipment and infrastructure.

(D) Establishment of a coordinated research and development program for the prevention and mitigation of corrosion for new and existing military equipment and infrastructure that includes a plan to transition new corrosion prevention technologies into operational systems.

(3) The strategy shall include, for the matters specified in paragraph (2), the following:

(A) Policy guidance.

(B) Performance measures and milestones.

(C) An assessment of the necessary personnel and funding necessary to accomplish the long-term strategy.

(d) DEFINITIONS—In this section:

(1) The term “corrosion” means the deterioration of a material or its properties due to a reaction of that material with its chemical environment.

(2) The term “military equipment” includes all weapon systems, weapon platforms, vehicles, and munitions of the Department of Defense, and the components of such items.

(3) The term “infrastructure” includes all buildings, structures, airfields, port facilities, surface and subterranean utility systems, heating and cooling systems, fuel tanks, pavements, and bridges.

(2) The table of sections at the beginning of such chapter is amended by adding at the end the following new item:

§ 2228. Military equipment and infrastructure: prevention and mitigation of corrosion.

(b) DEADLINE FOR DESIGNATION OF RESPONSIBLE OFFICIAL OR ORGANIZATION.—The Secretary of Defense shall designate an officer, employee, or standing board or committee of the Department of Defense under subsection (a) of section 2228 of title 10, United States Code, as added by subsection (a), not later than 90 days after the date of the enactment of this Act.

(c) INTERIM REPORT.—When the President submits the budget for fiscal year 2004 to Congress pursuant to section 1105(a) of title 31, United States Code, the Secretary of Defense shall submit to Congress a report regarding the actions taken to that date under section 2228 of title 10, United States Code, as added by subsection (a). That report shall include the following:

(1) A description of the organizational structure for the personnel carrying out the responsibilities of the official or organization designated under subsection (a) of that section with respect to the prevention and mitigation of corrosion.

(2) An outline for the long-term strategy for prevention and mitigation of corrosion required by subsection (c) of that section and milestones for development of that strategy.

(d) DEADLINE FOR LONG-TERM STRATEGY.—The Secretary of Defense shall submit to Congress a report setting forth the long-term strategy required under subsection (c) of section 2228 of title 10, United States Code, as added by subsection (a), not later than one year after the date of the enactment of this Act.

(e) GAO REVIEW.—The Comptroller General shall monitor the implementation of the long-term strategy required under subsection (c) of section 2228 of title 10, United States Code, as added by subsection (a), and, not later than 18 months after the date of the enactment of this Act, shall submit to Congress an assessment of the extent to which that strategy has been implemented.

Appendix D
Compliance Matrices

10 U.S.C. 2228

	Policy guidance	Performance measures and milestones	An assessment of the necessary personnel and funding necessary to accomplish the long-term strategy
Expansion of the emphasis on corrosion prevention and mitigation within the Department of Defense to include coverage of infrastructure.	Pages I-6, I-7, I-8; II-3, II-4; III-3, III-4; Appendix A	Pages I-5; III-9, III-10	Pages II-1, II-4; III-4 through III-6, III-11, III-12
Application uniformly throughout the Department of Defense of requirements and criteria for the testing and certification of new corrosion-prevention technologies for equipment and infrastructure with similar characteristics, similar missions, or similar operating environments.	Pages I-6, I-7, I-8; II-3, II-4; III-3, III-4; Appendix A	Pages I-5; III-9, III-10	Pages II-1, II-4; III-4 through III-6, III-11, III-12
Implementation of programs, including supporting databases, to ensure that a focused and coordinated approach is taken throughout the Department of Defense to collect, review, validate, and distribute information on proven methods and products that are relevant to the prevention of corrosion of military equipment and infrastructure.	Pages I-6, I-7, I-8; II-3, II-4; III-3, III-4; Appendix A	Pages I-5; III-9, III-10	Pages II-1, II-4; III-4 through III-6, III-11, III-12
Establishment of a coordinated research and development program for the prevention and mitigation of corrosion for new and existing military equipment and infrastructure that includes a plan to transition new corrosion prevention technologies into operational systems.	Pages I-6, I-7, I-8; II-3, II-4; III-3, III-4; Appendix A	Pages I-5; III-9, III-10	Pages II-1, II-4; III-4 through III-7, III-11, III-12

Interim Report to Congress and GAO-03-753

Item	Reference page #
Interim Report to Congress	
Service roll-up of equipment being replaced or refurbished.	Page III-6
A review of expanding corrosion initiatives	Section IV
Service roll-up of their corrosion efforts and the status	Page III-6
GAO-03-753 Opportunities to Reduce Corrosion Costs and Increase Readiness	
Strategic Plan should include development of standardized methodologies for collecting and analyzing corrosion cost, readiness, and safety data	Pages III-7 through III-9
Strategic Plan should include development of clearly defined goals, out-come orientated objectives, and performance measures that show progress toward achieving objectives (these measures should include such elements as the expected return on investment and realized net savings of prevention projects)	Pages I-5; III-9 through III-11
Strategic Plan should identify the level of resources needed to accomplish goals and objectives	Pages II-1; II-4; III-4 through III-6, III-11, III-12
Strategic Plan should establish mechanisms to coordinate and oversee prevention and mitigation projects in an interservice and service-wide context	Pages III-29 through III-34
Service secretaries should develop service-wide plans that are consistent with the goals, objectives, and measures in the department-wide plan	Awaiting publication of DoD Strategic Plan
Service secretaries should establish procedures and milestones to hold major commands and program offices that manage specific weapon systems and facilities accountable for achieving the strategic goals	Awaiting publication of DoD Strategic Plan

Appendix E
Summary of Corrosion Control Citations

Table E-1 contains the compilation of corrosion-relation citations that identifies over 142,000 corrosion-related reports available from AMPTIAC, the Defense RDT&E On-Line System (DROLS), NASA, the Department of Energy, the Department of Transportation, and the Department of Commerce. The information contained within this table indicates there is a wealth of government-developed information available to assess current problems. Table E-1 was developed and provided by AMPTIAC.

Table E-1. Summary of Corrosion Control Citations

	AMPTIAC	DROLS	NASA	DOE	DOT	DOC[a]
Total Available Corrosion Reports	**22972**	**37781**	**27589**	**42745**	**4256**	**6697**
By Application						
Aircraft	1645	4272	2104	442	68	444
Space	792	1650	508	1146	122	198
Ship	1045	1907	63	530	519	104
Submarine	101	498	11	49	14	9
Vehicle	336	1295	107	528	361	99
Infrastructure (bridges, dams, pier, pipeline)	368	779	456	970	1853	412
Industrial	632	9633	508	2958	108	284
Electronics	408	1791	349	882	46	54
By Mechanism						
Uniform *or* General	582	332	959	827	451	578
Galvanic	901	1157	382	350	168	129
Crevice	1101	1171	315	564	105	147
Pitting	2573	2828	1085	1487	212	382
Intergranular	1800	2015	1524	1574	32	226
Selective Leaching *or* Dealloying	26	44	21	43	5	6
Stress Corrosion Cracking	2546	3607	3981	1910	228	638
Erosion	770	1340	907	13630	181	260
Corrosion Fatigue	1147	1484	855	536	213	549
Hydrogen	2351	3187	1768	7660	133	474
Microbiological (biofouling)	111	171	44	75	14	50
Exfoliation	304	343	146	46	4	14
Fretting	190	226	444	117	20	40
High Temperature Corrosion	170	412	381	177	19	1011
Oxidation	2224	6000	2419	5814	170	594

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Total Available Corrosion Reports	**22972**	**37781**	**27589**	**42745**	**4256**	**6697**
By Environment						
Environmental	6700	9362	1285	3056	1182	835
Atmospheric *or* atmosphere	1368	1836	969	1988	248	325
Marine	1180	6046	482	563	595	214
Seawater	1962	2802	5342	735	426	145
Tropical	64	252	45	27	16	2
Space	786	1652	508	1146	122	198
High Temperature	2104	3596	3716	7916	100	1012
Industrial	629	9633	508	2958	108	284
Chemical	4708	5425	2842	19844	713	1309
By Protection Method						
Coating	4195	3806	1716	5654	878	591
Sealant	158	309	35	42	33	16
Primer	346	699	162	67	137	66
Inhibitor	939	1548	313	853	334	116
Cathodic	1389	1929	658	1275	613	299
Anodic	1997	2412	856	953	136	139
Protect [a]	2891	6435	3624	8500	2380	1297
Prevent [a]	1034	2031	3609	1739	1193	688
Passivation	968	1037	389	823	48	107
Mitigation	29	136	38	221	64	67
Control	2219	3831	1492	5303	864	903
By Testing and Inspection						
Testing	3349	19099	1853	11560	2088	1399
Accelerated	147	324	0	31	190	92
Natural (Field Test, In-service Test)	218	378	140	121	239	145
Inspection	628	2655	634	1439	463	516
Monitoring	301	1165	362	2013	375	359
Non-destructive	550	2107	618	1274	151	310
Neutron Radiography	22	86	30	42	3	12
Digital Radiography	2	8	3	5	0	1
Guided Wave Ultrasonic	0	4	0	9	0	3
Microwave *and* NDE	9	9	1	3	2	18
Magneto-optic Eddy Current Imaging	1	8	7	1	0	0
AC Magnetic Bridge Scanning	0	1	0	0	0	0
Multi-frequency Eddy Current	0	0	0	2	0	1
Thermal Imaging	9	30	10	41	3	24
Optically Aided Visual Inspection	1	2	1	0	0	0

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Total Available Corrosion Reports	**22972**	**37781**	**27589**	**42745**	**4256**	**6697**
By Material Class						
Metal	7138	15331	5694	31255	874	1218
Ceramic	1148	2195	850	11120	63	380
Polymer *or* Plastic	1027	4099	44715	2436	493	310
Composite	1750	5974	1040	1496	417	470
Electronic	350	1782	293	904	30	109
Optical	530	1075	599	877	28	172
By Specific Metals						
Steel	9417	13163	3466	14596	2573	1615
Aluminum	6084	8844	4808	3959	369	748
Titanium	3477	4399	2184	3981	108	383
Nickel	4516	6007	2577	9329	196	514
Superalloy	695	803	523	396	8	19
Magnesium	1585	2227	780	1467	140	119
Copper	1597	2675	1031	2954	230	446
Zinc	875	1660	720	1128	325	200
Tin	223	559	249	1233	19	76
Cadmium	262	520	162	417	16	46
Refractory Metal	136	326	322	454	0	31
By System Component						
Joint	1119	2003	273	916	310	139
Lap	175	191	63	4	2	18
Butt	77	93	10	7	14	3
Weld	2460	3313	394	972	399	140
Gasket	47	108	17	36	6	7
Seal	95	1305	114	297	185	55
Fastener (bolt, rivet)	210	1205	228	68	136	51
Stiffener	20	36	8	0	5	4
Valve	153	463	75	323	76	42
Connector	91	347	17	23	26	9
Skin	256	410	189	53	20	46
Hull	168	636	17	48	281	31
Armor	85	215	25	26	6	16
Bearing	470	670	287	208	82	187
Housing	87	317	30	85	25	19
Engine	4302	2966	790	517	237	134
Piping	408	844	118	1164	94	187

Table E-1. Summary of Corrosion Control Citations

	AMPTIAC	DROLS	NASA	DOE	DOT	DOC[a]
Total Available Corrosion Reports	**22972**	**37781**	**27589**	**42745**	**4256**	**6697**
General Maintenance Terms						
Maintenance	563	1522	682	1276	859	560
Repair	444	800	275	536	509	222
Replace[a]	369	764	396	916	228	270
Preserv [a]	90	359	68	137	79	41
General Management Terms						
Manag [a]	162	771	218	3364	203	466
Policy (polic [a])	23	56	42	475	26	48
Training	150	273	34	124	67	36
Awareness	206	23	12	22	21	9
Forum	34	92	11	146	11	19
Workshop	36	181	42	346	30	64
Conference	1161	3672	138	3285	86	117
Cost	1184	1962	898	1679	756	445
Corrosion Control Plan (CCP)	2	4	2	0	1	0
Corrosion Prevention and Control (CPAC)	46	80	459	5	11	5
Studies/Policies						
Benchmark	4	11	7	48	2	8
Standard	777	1721	403	953	310	234
Specification	389	1976	109	280	321	83
Requirement [a]	650	2023	86	1469	290	410
Technical manual	10	12	4	3	1	3
Documentation	27	4284	59	123	128	58
Survey	350	1039	148	672	303	140

[a] Since 1990.

Appendix F
Abbreviations

A&T	acquisition and technology
AAIPT	Aging Aircraft Integrated Product Team
AFRL	Air Force Research Laboratory
ALC	Air Logistics Center
AMC	Army Materiel Command
AMPTIAC	Advanced Materials and Processes Technology Information Analysis Center
AR	Army Regulation
ARL	Army Research Laboratory
ASSIST	Acquisition Streamlining and Standardization Information System
AT&L	acquisition, technology, and logistics
CARC	chemical agent–resistant coating (paint)
CERL	Construction Engineering Research Laboratory
CFFT	Corrosion Fleet Focus Team
CMO	Corrosion Management Office
COE	Corps of Engineers
CP	cathodic prevention
CPC	Corrosion Prevention and Control and Corrosion Preventive Compounds
CPCIPT	Corrosion Prevention and Control Integrated Product Team
CPT	corrosion prevention technology
CSG	Corrosion Steering Group
DAB	Defense Acquisition Board

DCU	data acquisitions unit
DDR&E	Director of Defense Research and Engineering
DFARS	Defense Federal Acquisition Regulation Supplement
DOC	Department of Commerce
DOE	Department of Energy
DOT	Department of Transportation
DPG	*Defense Planning Guidance*
DROLS	Defense RDT&E Online System
DTL	Detail specification (i.e., MIL-DTL)
ECD	estimated completion date
ESTCP	Environmental Security Technology Certification Program
FRP	fiberglass reinforced polymer
FYDP	Future Years Defense Program
GAO	General Accounting Office
HAP	Hazardous Air Pollutant
HDBK	Handbook
HMMWV	High Mobility Multipurpose Wheeled Vehicle
IPT	integrated product team
IRAC	interim rapid action change
IVHM	integrated vehicle health monitoring
JACG	Joint Aeronautical Commanders Group
JCAA	Joint Council on Aging Aircraft
JTPs	joint test protocols
M&P	materials and processes

MAUS	Mobile Automated Scanner
MEMS	micro-electromechanical systems
MIL	military specification (e.g., MIL-DTL [detail specification] and MIL-PRF [performance based specification])
NACE	National Association of Corrosion Engineers
NASA	National Aeronautics and Space Administration
NAVAIR	Naval Air Systems Command
NAVSEA	Naval Sea Systems Command
NDAA	National Defense Authorization Act
NDE	nondestructive evaluation
NDI	nondestructive inspection
NDT	nondestructive testing
NPV	net present value
O&M	operations and maintenance
ONR	Office of Naval Research
OSD	Office of the Secretary of Defense
OUSD	Office of the Under Secretary of Defense
PDUSD	Principal Deputy Under Secretary of Defense
POL	petroleum, oil, and lubricants
PPBE	Planning, Programming, Budgeting, and Execution
PRCRP	Pacific Rim Corrosion Research Program
PTO	Pacific Theater of Operations
QPL	Qualified Products List
R&D	research and development

RD&E	research, development, and engineering
RDT&E	research, development, test, and evaluation
ROI	return on investment
S&T	science and technology
SERDP	Strategic Environmental Research and Development Program
SSQP	Specifications, Standards, and Qualification Process
TARDEC	Tank-Automotive Research and Development Engineering Center
TLR	technology level readiness
TRI	multiple Services (as in TRI-Service)
UFC	Unified Facilities Criteria
UHM	University of Hawaii, Manoa
VOCs	volatile organic compounds
WIPT	working integrated product team